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CORRECTIVE MEASURES STUDY REPORT COMBINED SOLID WASTE MANAGEMENT UNIT 70 (SWMU 70) ZONE E CNC CHARLESTON SC

8/11/2003

CH2M HILL

CORRECTIVE MEASURES STUDY REPORT

Combined SWMU 70, Zone E

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

CH2M Jones

July 2003

Contract N62467-99-C-0960

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CH2MHILL

August 11, 2003

Mr. David Scaturo
South Carolina Department of Health and
Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Re: CMS Report (Revision 0) – Combined SWMU 70, Zone E

Dear Mr. Scaturo:

Enclosed please find two copies of the CMS Report (Revision 0) for Combined SWMU 70 in Zone E of the Charleston Naval Complex (CNC). This report has been prepared pursuant to agreements by the CNC BRAC Cleanup Team for completing the RCRA Corrective Action process.

The principal author of this document is Paul Favara. Please contact him at 352/335-5877, ext. 2396, if you have any questions or comments.

Sincerely,

CH2M HILL

Dean Williamson, P.E.

cc: Tim Frederick/Gannett-Fleming, Inc., w/att
Dann Spariosu/USEPA, w/att
Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

CORRECTIVE MEASURES STUDY REPORT

Combined SWMU 70, Zone E

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
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PREPARED BY
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July 2003

Revision 0
Contract N62467-99-C-0960
158814.ZE.EX.03

Certification Page for Corrective Measures Study Report (Revision 0) — Combined SWMU 70, Zone E

I, Dean Williamson, certify that this report has been prepared under my direct supervision. The data and information are, to the best of my knowledge, accurate and correct, and the report has been prepared in accordance with current standards of practice for engineering.

South Carolina

P.E. No. 21428

____

Dean Williamson, P.E.

____

Date

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Acronyms and Abbreviations

AOC	area of concern
AST	aboveground storage tank
BCT	BRAC Cleanup Team
BEQ	benzo[a]pyrene equivalent
BRAC	Base Realignment and Closure Act
CA	corrective action
CMS	corrective measures study
CNC	Charleston Naval Complex
COC	chemical of concern
COPC	chemical of potential concern
CVOC	chlorinated volatile organic compound
DAF	dilution attenuation factor
DET	Environmental Detachment Charleston
EnSafe	EnSafe, Inc.
EPA	U.S. Environmental Protection Agency
ft^2	square feet
ft bls	feet below land surface
HI	hazard index
ILCR	Incremental Lifetime Cancer Risk
IM	interim measure
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
LUC	land use control
LUCIP	land use control implementation plan
LUCMP	land use control management plan
mg/kg	milligram per kilogram
MCL	maximum contaminant level
MCS	media cleanup standard

Acronyms and Abbreviations, Continued

NAVBASE	Naval Base
ORP	Oxidation Reduction Potential
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PPE	personal protective equipment
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RDA	Redevelopment Authority
RFI	RCRA Facility Investigation
RGO	remedial goal option
SCDHEC	South Carolina Department of Health and Environmental Control
SPLP	synthetic precipitation leaching procedure
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TCE	trichloroethene
TTA	target treatment area
VOC	volatile organic compound
y^3	cubic yard
ZVI	zero-valent iron

1.0 Introduction

In 1993, Naval Base (NAVBASE) Charleston was added to the list of bases scheduled for closure as part of the Defense Base Realignment and Closure (BRAC) Act, which regulates closure and transition of property to the community. The Charleston Naval Complex (CNC) was formed as a result of the dis-establishment of the Charleston Naval Shipyard and NAVBASE on April 1, 1996.

CNC Corrective Action (CA) activities are being conducted under the Resource Conservation and Recovery Act (RCRA); the South Carolina Department of Health and Environmental Control (SCDHEC) is the lead agency for CA activities at the site. All RCRA CA activities are performed in accordance with the Final Permit (Permit No. SC0 170 022 560).

In April 2000, CH2M-Jones was awarded a contract to provide environmental investigation and remediation services at the CNC. This submittal has been prepared by CH2M-Jones to complete the Corrective Measures Study (CMS) for Solid Waste Management Units (SWMUs) 22, 25, and 70, and Areas of Concern (AOCs) 548, 549, and 554. This group of sites is referred to as Combined SWMU 70.

Figure 1-1 presents the location of Zone E within the CNC and the location of Combined SWMU 70 in Zone E.

1.1 Corrective Measures Study Report Purpose and Scope

This CMS report evaluates CA alternatives for chemicals of concern (COCs) in soil and groundwater at Combined SWMU 70 and develops the basis for selection of a CA.

Combined SWMU 70 consists of:

- SWMU 22, the Old Plating Shop Wastewater Treatment System, was originally constructed in 1972 and is located on the southeast side of Building 5.
- SWMU 25, an electroplating operation located near the southwestern portion of Building 5, was operational until 1983.
- AOC 554 is the former Building 1003 location. Building 1003 was used as a paint shop from approximately 1909 to 1940.

- SWMU 70 consists of a former dip tank at the northwest corner of Building 5. The dip tank was used to treat wood with a fire retardant chemical.
- AOC 548, an electric hydraulic elevator, is located on the western side of Building 5. The elevator is in a shaft that is paved on the bottom with approximately 8 inches of concrete.
- AOC 549 is the site of a former scrap yard north of Building 5, which was in operation during the 1920s and 1930s.

A summary of the COCs and proposed media cleanup standards (MCSs) that were identified at Combined SWMU 70 are presented in *RCRA Facility Investigation (RFI) Report Addendum and CMS Work Plan, Combined SWMU 70, Zone E* (CH2M-Jones, 2002a). That report evaluated and refined the COCs identified at Combined SWMU 70 as presented in the *Zone E RFI Report, Revision 0* (EnSafe Inc. [EnSafe], 1997).

In addition, this CMS report presents the results of the ongoing pilot study being conducted for groundwater treatment at Combined SWMU 70 and the results of additional soil samples collected to assess current site conditions.

1.2 Site Regulatory History

Combined SWMU 70 was originally addressed in the *Zone E RFI Report, Revision 0* (1997). A series of interim measures (IMs) have been completed at SWMU 25:

- In April 1997, the Building 44 Annex was demolished and the building material was removed from the site;
- In June 1998, 6,203 pounds of chromium-contaminated fluid were removed from an electrical vault at SWMU 25;
- In July 1999, the electrical service vault and associated cables were removed from SWMU 25. Soil was placed as backfill and the site was capped with asphalt;
- In early 1999, a SWMU 25 storm-sewer pipe segment was cleaned out.

Details of the IMs completed at SWMU 25 are presented in Section 3.0 of the *RFI Report Addendum and CMS Work Plan* (CH2M-Jones, 2002a). IM Completion reports are also included as Appendix B to the *RFI Report Addendum and CMS Work Plan*.

In addition to the above referenced CMS Work Plan, two other CMS Work Plans have been submitted for Combined SWMU 70. *Phase I – Groundwater Delineation, CMS Work Plan, Revision 1,* which was submitted in December 2000, presented a sampling plan to characterize hexavalent chromium in groundwater. The results of the characterization effort were presented in *Phase II CMS Work Plan, In situ Reduction of Hexavalent Chromium Using ZVI, Revision 1* (CH2M-Jones, 2002b) which was submitted in January 2002, along with a pilot study work plan to evaluate the ability of zero-valent iron (ZVI) (emplaced by pneumatic fracturing) to reduce hexavalent chromium. Findings from this pilot study were presented in the *RFI Report Addendum and CMS Work Plan* (CH2M-Jones, 2002a). A status update of the ongoing performance of the injected ZVI is provided in Section 3.3 of this CMS report.

The *RFI Work Plan and CMS Work Plan* identified a data gap for soils in the SWMU 25 area and recommended the collection of new soil samples at this site. The additional site information was required because:

- The IMs completed by the Environmental Detachment Charleston (DET) subsequent to the original RFI involved the removal of considerable quantities of soil. Because these IMs likely changed the distribution of soil contaminants as reported in *Zone E RFI Report, Revision 0* additional soil samples were collected. The new soil data collected at SWMU 25 (discussed in Section 2.0) covered the full extent of SWMU 25 and provides a current understanding of the distribution of soil COCs.
- The CMS Work Plan identified several metals as COCs based on their potential to impact groundwater via leachability. Soil samples were collected from SWMU 25 to complete synthetic precipitation leaching procedure (SPLP) analyses and develop site-specific partitioning coefficients for several metals defined as COCs, due to leachability, in the CMS Work Plan. The site-specific leachability values are used in lieu of the literature values that were used in the CMS Work Plan to calculate site-specific SSLs.

1.3 Report Organization

This CMS report consists of the following sections, including this introductory section:

1.0 Introduction —Presents the purpose and scope of the CMS, as well as relevant background information.

2.0 Refinement of COCs —Screens soil samples collected in December 2002 to further refine the list of COCs presented in the CMS Work Plan. Additionally, new data for antimony in groundwater are screened.

3.0 Site Hydrogeology, Nature and Extent of Contamination — Presents a summary of current site conditions, integrating the results of the new soil data collected at SWMU 25, summarizes groundwater characterization information presented in the RFI Report Addendum, and presents updated data for the pilot study initiated in January 2002.

4.0 RAOs, Proposed MCSs, and Alternative Evaluation Criteria — Presents the remedial action objectives (RAOs) of this CMS and presents proposed MCSs for COCs.

5.0 Description of Candidate Corrective Measure Alternatives — Describes each of the candidate corrective measure alternatives.

6.0 Detailed Analysis of Alternatives —Presents a detailed analysis of alternatives for CA at Combined SWMU 70.

7.0 Recommended Corrective Measure Alternative—Describes the preferred corrective measure alternative to achieve the MCSs and RGOs for Combined SWMU 70.

8.0 References — Lists the references used in this document.

Appendix A provides figures showing Zone E site-specific features.

Appendix B provides a summary table of data collected in December 2002 and SPLP calculations.

Appendix C provides the cost estimates for each corrective measure alternative evaluated in this CMS.

All tables and figures appear at the end of their respective sections.

Figure 1-1
Location of Combined SWMU 70
in Zone E
Charleston Naval Complex

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File Path: c:\18gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 16 Sep 2002 15:07, User: PFAVARA, RFIRA-CMSWP: Figure 1-1 Location of Combined SWMU 70

2.0 COC Refinement

This section presents the results of analysis of soil samples collected at SWMU 25 in December 2002 with a focus on refinement of COCs that were presented in the CMS Work Plan. Additionally, new data for antimony in groundwater are assessed for the purpose of COC refinement.

2.1 COC Refinement for Soil

Several IMs completed by the DET at SWMU 25 involved removal or disruption of soil , thus rendering the previous soil characterization results non-representative. As discussed in the *RFI Report Addendum and CMS Work Plan,* additional soil samples were collected to re-characterize the nature of COCs in soils; these soil samples were collected in December 2002.

The locations of surface and subsurface soil samples are presented in Figure 2-1 (11 surface and subsurface soil samples). Surface and subsurface soil results for antimony, cadmium, chromium, and hexavalent chromium (i.e., the COCs in soils, as identified by the CMS Work Plan) are presented in Tables 2-1 and 2-2, respectively.

2.1.1 Evaluation of Human Health COCs

This risk assessment presented in the CMS Work Plan identified two COCs in soil based on the exposure pathway to humans – hexavalent chromium and BEQs. The BEQs reported at the site were a COC because they exceeded sitewide reference concentrations, which are greater than risk-based levels. Hexavalent chromium was a COC based on risk to child residential receptors. Based on this, a MCS for hexavalent chromium was developed to protect child residential receptors; this value was established at 230 milligram per kilogram (mg/kg).

The data collected in December 2002 were compared to the data used for the risk assessment presented in the CMS Work Plan. These risk assessment data were based on the original RFI data and, because of the IMs completed after the collection of these samples, were considered to be potentially non-representative of site conditions. The concentrations reported for the metal COCs in the December 2002 sampling event were generally less than the reported concentrations used in the risk assessment. With this information, it can be concluded that the IMs completed at SWMU 25 resulted in a decrease in overall COC concentrations at SWMU 25. Based on the lower concentrations reported at SWMU 25, it was not necessary to re-evaluate the risk assessment.

The data presented in Tables 2-1 and 2-2 can be used to evaluate relative risk. Based on these data, it can be concluded there are no unacceptable risks to residential receptors because:

- An MCS was developed for hexavalent chromium, and this MCS is protective of child receptors;
- All concentrations of hexavalent chromium reported for SWMU 25 in December 2002 (Tables 2-1 and 2-2) are substantially less than the MCS.
- The concentration of antimony, cadmium, and total chromium reported in December 2002 are less than samples used to estimate exposure concentrations in the risk assessment. Because these constituents were not identified as COCs in the Risk Assessment, lower concentrations reported in December 2002 would also result in a conclusion that these constituents are not COCs based on human receptors.

2.1.2 Evaluation of Leachability COCs

SPLP data were collected to evaluate site-specific leachability characteristics of specific metals in soil. A total of 11 samples were analyzed for SPLP, specifically:

E025SB028 (0-1 ft)
E025SB028 (3-5 ft)
E025SB029 (0-1 ft)
E025SB029 (3-5 ft)
E025SB031 (0-1 ft)
E025SB031 (3-5 ft)
E025SB033 (0-1 ft)
E025SB033 (3-5 ft)
E025SB035 (0-1 ft)
E025SB037 (0-1 ft)
E025SB038 (3-5 ft)

The samples above were selected to represent a range of contaminant concentrations in soil, to allow a partitioning coefficient to be calculated. SPLP samples for antimony were not necessary due to its relatively low frequency of detection and concentration.

The data summary table for the SPLP analyses is presented in Appendix B-1. The data were evaluated to determine the partitioning coefficient of COCs with soil. This information was used to derive site-specific SSLs that were based on the sites physical and chemical properties; the previous SSL values reported in the RFI Report Addendum and CMS Work Plan were based on published literature values for partitioning values.

The site-specific SSL calculations and values, using the new SPLP data, are presented in Appendix B-2. The results are summarized below:

	Unpaved SSL (DAF* = 2.8)	Paved SSL (DAF = 17.8)
Cd	24 mg/kg	151 mg/kg
Cr^{+3}	281,760 mg/kg	Not Leachable**
Cr^{+6}	9 mg/kg	56 mg/kg

*dilution attenuation factor

**A value of 1,760,000 mg/kg was calculated for the paved based SSL, which is greater than maximum concentration that can be present.

As agreed to by the BCT, SSLs were calculated for both the paved and unpaved scenarios. If the average concentration of the constituent is above the paved SSL, it is a COC for the paved and unpaved scenario. If the average concentration is greater than the unpaved SSL, but less than the paved SSL, it is retained as a COC for the unpaved scenario only. If the average concentration is less than the unpaved SSL, it is not a COC for either scenario.

The December 2002 surface and subsurface SPLP data are screened in Tables 2-1 and 2-2, respectively. Each of the screened constituents is discussed below.

2.1.2.1 Antimony

Surface and subsurface antimony results for the December 2002 sampling event are presented in Tables 2-1 and 2-2, respectively. In surface soil, three soil samples exceeded the unpaved SSL and no samples exceeded the paved SSL. The site-specific SSL developed for antimony was based on literature partitioning data. The average concentration of antimony in surface soil is 1.15 mg/kg, which is greater than the unpaved SSL but less than the paved SSL.

In subsurface soil, three soil samples exceeded the unpaved SSL and one sample exceeded the paved SSL. The site-specific SSL developed for antimony was based on literature partitioning data. The average concentration of antimony in subsurface soil is 1.59 mg/kg, which is greater than the unpaved SSL but less than the paved SSL.

The sitewide averages indicate the antimony in soil at SWMU 25 does not represent a threat to groundwater when pavement is present. Antimony is retained as a soil COC as it represents a potential threat to groundwater in the event that pavement is not maintained at the site (i.e., unrestricted land use).

2.1.2.2 Cadmium

Surface and subsurface cadmium results for the December 2002 sampling event are presented in Tables 2-1 and 2-2, respectively. The site-specific SSL developed for cadmium was based on SPLP data.

In surface soil, one soil sample exceeded both the unpaved SSL and the paved SSL. The average concentration of cadmium in surface soil is 5.68 mg/kg, which is less than the unpaved and paved SSL.

In subsurface soil, one soil sample exceeded the unpaved and paved SSL. The average concentration of cadmium in subsurface soil is 9.56 mg/kg, which is less than the unpaved SSL and paved SSL.

The sitewide averages indicate that cadmium in soil at SWMU 25 does not represent a threat to groundwater. Therefore, cadmium should no longer be considered a soil COC at SWMU 25.

2.1.2.3 Chromium

Surface and subsurface chromium results for the December 2002 sampling event are presented in Tables 2-1 and 2-2, respectively. The site-specific SSL developed for chromium was based on SPLP data.

No surface or subsurface soil samples exceeded the paved or unpaved SSL. The SPLP data showed chromium to be tightly bound to the soil matrix, as indicated by the very low chromium results reported in SPLP extracts. This indicates chromium in soil at SWMU 25 does not represent a threat to groundwater. Therefore, chromium should no longer be considered a soil COC at SWMU 25.

2.1.2.4 Hexavalent Chromium

Surface and subsurface hexavalent chromium results for the December 2002 sampling event are presented in Tables 2-1 and 2-2, respectively. The site-specific SSL developed for hexavalent chromium was based on SPLP data.

In surface soil, four soil samples exceeded the unpaved SSL and one sample exceeded the paved SSL. The average concentration of hexavalent chromium in surface soil is 12.8 mg/kg, which is greater than the unpaved SSL and less than the paved SSL.

In subsurface soil, four soil samples exceeded the unpaved SSL and two samples exceeded the paved SSL. The average concentration of chromium in subsurface soil is 17.4 mg/kg, which is greater than the unpaved SSL but less than the paved SSL (i.e., unrestricted landuse).

Hexavalent chromium is retained as a soil COC as it represents a potential threat to groundwater in the event that pavement is not maintained at the site.

2.1.2.5 BEQs

BEQs results for surface soil are presented in Table 2-1. Subsurface soils were not targeted for BEQs as they did not exceed screening criteria, as reported in the RFI Report Addendum. One sample exceeded the BEQ sitewide reference concentration of 1,304 micrograms per kilogram (μg/kg). The results of the December 2002 sampling event confirm the previous data, which indicated a very localized elevated area of BEQs in surface soils (one previous sample collected near E025SB036 from the area was reported with a concentration of 4,853 μg/kg BEQs). Based on this information, BEQ remains a surface soil COC for the Combined SMWU 70 area.

2.2 COC Refinement for Groundwater

2.2.1 Antimony

Antimony was reported to exceed maximum contaminant levels (MCLs) in four wells over the course of the RFI. Careful evaluation of the data in Table 2-4 show that while antimony exceeded the MCL before any IMs were completed (April 1997), after this date, all groundwater concentrations are below MCLs. Based on this information, the remedial alternatives do not need to address antimony. The data in Table 2-4, along with the results of antimony in soil reported in the previous section and Section 3.0, indicate the effectiveness of the IM in removing contaminated source material and potentially leachable material. Based on this assessment, antimony in groundwater should no longer be considered a COC.

2.3 COC Summary

Based on the data presented in Sections 2.1 and 2.2, the following constituents were removed from the COC list that was presented in the CMS Work Plan:

- Antimony in groundwater – groundwater data from post-IM sampling events show decreased concentrations, indicating that the source of antimony in soil had been removed and the asphalt cap is effective in reducing infiltration that would mobilize antimony.
- Total chromium in soil – SPLP results show this constituent is not leachable and, therefore, does not represent a threat to groundwater.
- Cadmium in soil – SPLP results show cadmium in soil at SWMU 25 is not very mobile and does not represent a threat to groundwater.

Table 2-3 shows the revised list of COCs for Combined SWMU 70. Those constituents that were removed from the list as part of the COC refinement process presented in this section are stricken out and highlighted.

TABLE 2-1
SWMU 25 COC Refinement with December 2002 Surface Data
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Chemical	Station ID	Sample ID	Date Collected	Result (mg/kg)	Qualifier	Zone E Range of Background Concentrations		SSL (DAF=17.8)		SSL (DAF=2.8)	
						Minimum	Maximum				
Antimony	E025SB028	025SB02801	12/23/02	0.688	UJ	0.5	7.4	4.5	SSG	0.7	SSG
	E025SB029	025SB02901	12/23/02	0.692	UJ						
	E025SB030	025SB03001	12/23/02	0.686	UJ						
	E025SB031	025SB03101	12/23/02	0.676	UJ						
	E025SB032	025SB03201	12/23/02	0.734	UJ						
	E025SB033	025SB03301	12/23/02	1.26	J						
	E025SB034	025SB03401	12/23/02	0.729	UJ						
	E025SB035	025SB03501	12/23/02	0.727	UJ						
	E025SB036	025SB03601	12/23/02	0.71	UJ						
	E025SB037	025SB03701	12/23/02	2.63	J						
	E025SB038	025SB03801	12/23/02	3.16	J						
	Average			1.15							
Cadmium	E025SB028	025SB02801	12/23/02	43.4	=	0.06	1.5	151	SPLP	24	SPLP
	E025SB029	025SB02901	12/23/02	20.9	=						
	E025SB030	025SB03001	12/23/02	5.74	=						
	E025SB031	025SB03101	12/23/02	4.39	=						
	E025SB032	025SB03201	12/23/02	2.2	=						
	E025SB033	025SB03301	12/23/02	3.45	=						
	E025SB034	025SB03401	12/23/02	10.3	=						
	E025SB035	025SB03501	12/23/02	2.4	=						
	E025SB036	025SB03601	12/23/02	0.21	J						
	E025SB037	025SB03701	12/23/02	2.57	=						
	E025SB038	025SB03801	12/23/02	0.424	J						
	Average			8.73							
Chromium	E025SB028	025SB02801	12/23/02	122	=	2.3	567	1,761,635	SPLP	281,760	SPLP

TABLE 2-1
SWMU 25 COC Refinement with December 2002 Surface Data
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Chemical	Station ID	Sample ID	Date Collected	Result (mg/kg)	Qualifier	Zone E Range of Background Concentrations		SSL (DAF=17.8)		SSL (DAF=2.8)	
						Minimum	Maximum				
	E025SB029	025SB02901	12/23/02	40.5	=						
	E025SB030	025SB03001	12/23/02	171	=						
	E025SB031	025SB03101	12/23/02	1140	=						
	E025SB032	025SB03201	12/23/02	411	=						
	E025SB033	025SB03301	12/23/02	1710	=						
	E025SB034	025SB03401	12/23/02	541	=						
	E025SB035	025SB03501	12/23/02	634	=						
	E025SB036	025SB03601	12/23/02	126	=						
	E025SB037	025SB03701	12/23/02	3,390	=						
	E025SB038	025SB03801	12/23/02	7,790	=						
	Average			1,461							
Chromium (hexavalent, $Cr+^6$)	E025SB028	025SB02801	12/23/02	0.551	=	NA	NA	55.9	SPLP	9.0	SPLP
	E025SB029	025SB02901	12/23/02	2.06	=						
	E025SB030	025SB03001	12/23/02	2.78	=						
	E025SB031	025SB03101	12/23/02	2.11	=						
	E025SB032	025SB03201	12/23/02	12.9	=						
	E025SB033	025SB03301	12/23/02	9.33	=						
	E025SB034	025SB03401	12/23/02	37.2	=						
	E025SB035	025SB03501	12/23/02	3.88	=						
	E025SB036	025SB03601	12/23/02	1.75	=						
	E025SB037	025SB03701	12/23/02	1.72	=	12.82					
	E025SB038	025SB03801	12/23/02	[redacted]	=						
	Average			12.8							
BEQs	E025SB028	025SB02801	12/23/02	0.156	J	NA	1.304	NA	NA	NA	NA
	E025SB029	025SB02901	12/23/02	0.042	U						

TABLE 2-1
SWMU 25 COC Refinement with December 2002 Surface Data
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Chemical	Station ID	Sample ID	Date Collected	Result (mg/kg)	Qualifier	Zone E Range of Background Concentrations Minimum	Zone E Range of Background Concentrations Maximum	SSL (DAF=17.8)	SSL (DAF=2.8)
	E025SB030	025SB03001	12/23/02	0.243	J				
	E025SB031	025SB03101	12/23/02	0.043	U				
	E025SB032	025SB03201	12/23/02	0.043	J				
	E025SB033	025SB03301	12/23/02	0.210	J				
	E025SB034	025SB03401	12/23/02	0.075	J				
	E025SB035	025SB03501	12/23/02	0.284	J				
	E025SB036	025SB03601	12/23/02	**4.85**	J				
	E025SB037	025SB03701	12/23/02	0.358	J				
	E025SB038	025SB03801	12/23/02	0.277	J				

SPLP indicates that the SSL was calculated from site-specific SPLP data.

SSG indicates that the SSL was interpolated from the generic SSLs presented in the Soil Screening Guidance: Technical Background Document, U.S. Environmental Protection Agency (EPA), 1996, based on the calculated site-specific dilution attenuation factor (DAF) determined from the SPLP analysis.

NA indicates that the information is not available or not applicable.

U indicates that the compound was not detected. The reported value is the detection limit.

UJ indicates that the compound was not detected. The reported value is an estimated detection limit.

J indicates that the compound was detected. The reported value is an estimated concentration.

= indicates that the compound was detected. The reported value is the measured concentration.

TABLE 2-2
SWMU 25 COC Refinement with December 2002 Subsurface Data
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Chemical	Station ID	Sample ID	Date Collected	Result (mg/kg)	Qualifier	Zone E Range of Background Concentrations Minimum	Maximum	SSL (DAF=17.8)		SSL (DAF=2.8)	
Antimony	E025SB028	025SB02803	12/23/02	0.814	UJ	0.52	1.6	4.5	SSG	0.7	SSG
	E025SB029	025SB02903	12/23/02	0.783	UJ						
	E025SB030	025SB03003	12/23/02	0.722	UJ						
	E025SB031	025SB03103	12/23/02	0.831	UJ						
	E025SB032	025SB03203	12/23/02	0.724	UJ						
	E025SB033	025SB03303	12/23/02	1.22	J						
	E025SB034	025SB03403	12/23/02	0.798	UJ						
	E025SB035	025SB03503	12/23/02	0.718	UJ						
	E025SB036	025SB03603	12/23/02	0.707	UJ						
	E025SB037	025SB03703	12/23/02	3.91	J						
	E025SB038	025SB03803	12/23/02	6.25	J						
	Average			1.58							
Cadmium	E025SB028	025SB02803	12/23/02	24.4	J	0.13	0.96	151	SPLP	24	SPLP
	E025SB029	025SB02903	12/23/02	11.3	J						
	E025SB030	025SB03003	12/23/02	4.37	J						
	E025SB031	025SB03103	12/23/02	3.67	J						
	E025SB032	025SB03203	12/23/02	6.22	J						
	E025SB033	025SB03303	12/23/02	4.76	J						
	E025SB034	025SB03403	12/23/02	4.27	J						
	E025SB035	025SB03503	12/23/02	0.191	J						
	E025SB036	025SB03603	12/23/02	0.055	UJ						
	E025SB037	025SB03703	12/23/02	2.66	=						
	E025SB038	025SB03803	12/23/02	0.589	J						
	Average			5.68							
Chromium	E025SB028	025SB02803	12/23/02	49.3	J	1.6	75	1,761,635	SPLP	281,760	SPLP
	E025SB029	025SB02903	12/23/02	25.3	J						
	E025SB030	025SB03003	12/23/02	87.7	J						

TABLE 2-2
SWMU 25 COC Refinement with December 2002 Subsurface Data
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Chemical	Station ID	Sample ID	Date Collected	Result (mg/kg)	Qualifier	Zone E Range of Background Concentrations		SSL (DAF=17.8)		SSL (DAF=2.8)	
						Minimum	Maximum				
	E025SB031	025SB03103	12/23/02	838	J						
	E025SB032	025SB03203	12/23/02	349	J						
	E025SB033	025SB03303	12/23/02	1,300	J						
	E025SB034	025SB03403	12/23/02	628	J						
	E025SB035	025SB03503	12/23/02	391	J						
	E025SB036	025SB03603	12/23/02	232	J						
	E025SB037	025SB03703	12/23/02	5,870	=						
	E025SB038	025SB03803	12/23/02	10,000	=						
	Average				1,797						
Chromium (hexavalent, $Cr+^6$)	E025SB028	025SB02803	12/23/02	0.741	=	NA	NA	55.9	SPLP	9.0	SPLP
	E025SB029	025SB02903	12/23/02	0.54	=						
	E025SB030	025SB03003	12/23/02	0.489	=						
	E025SB031	025SB03103	12/23/02	4.89	=						
	E025SB032	025SB03203	12/23/02	20.2	=						
	E025SB033	025SB03303	12/23/02	0.737	=						
	E025SB034	025SB03403	12/23/02	11.9	=						
	E025SB035	025SB03503	12/23/02	2.59	=						
	E025SB036	025SB03603	12/23/02	1.98	=						
	E025SB037	025SB03703	12/23/02	65.8	=						
	E025SB038	025SB03803	12/23/02	81							
	Average			17.4	=						

SPLP indicates that the SSL was calculated from site-specific SPLP data. SSG indicates that the SSL was interpolated from the generic SSLs presented in the Soil Screening Guidance: Technical Background Document, EPA, 1996, based on the calculated site-specific dilution attenuation factor (DAF) determined from the SPLP analysis.

NA indicates that the information is not available or not applicable.

U indicates that the compound was not detected. The reported value is the detection limit.

UJ indicates that the compound was not detected. The reported value is an estimated detection limit.

J indicates that the compound was detected. The reported value is an estimated concentration.

= indicates that the compound was detected. The reported value is the measured concentration.

TABLE 2-2
SWMU 25 COC Refinement with December 2002 Subsurface Data
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Chemical	Station ID	Sample ID	Date Collected	Result (mg/kg)	Qualifier	Zone E Range of Background Concentrations Minimum	Zone E Range of Background Concentrations Maximum	SSL (DAF=17.8)	SSL (DAF=2.8)

[blank box] = Exceeds Unpaved SSL
[shaded box] = Exceeds Paved SSL

TABLE 2-3
COCs by Receptor and Media
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Receptor	BEQ	PCE	TCE	Vinyl Chloride	Hexavalent Chromium	Total Chromium	Cadmium	Antimony	
Industrial Worker	SS	G	G	G	G				
Utility Worker									
Residential Adult	SS	G	G	G	G			~~G~~	
Residential Child					SS G		G	G	
Surface Soil Leachability					SS	~~SS~~	~~SS~~	SS	PCE, (residential only)
Subsurface Soil Leachability					SB	~~SB~~	~~SB~~	SB	PCE, Methylene Chloride, Thallium (residential only)
Chemical Exceeding MCL		G	G	G	G	G	G	G	

~~G~~	Constituent was a COC in groundwater, based on the CMS Work Plan, but removed from the COC list as a result of post-CMS Work Plan COC refinement.
~~SB~~	Constituent was a COC in subsurface soil, based on the CMS Work Plan, but removed from the COC list as a result of post-CMS Work Plan COC refinement.
~~SS~~	Constituent was a COC in surface soil, based on the CMS Work Plan, but removed from the COC list as a result of post-CMS Work Plan COC refinement.
G	Groundwater
SB	Subsurface Soil
SS	Surface Soil

TABLE 2-4
Antimony Results in Wells with at Least One Historical MCL Exceedance
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

StationID	SampleID	AnaValue	Units	ProjQual	DateCollected
E025GW003	025GW00301	4.1	µg/L	J	04/26/96
E025GW003	025GW00302	6.3	µg/L	U	07/26/96
E025GW003	025GW00303	2.1	µg/L	U	12/02/96
E025GW003	025GW00304	13	µg/L	J	02/13/97
E025GW003	025GW003M5	4.79	µg/L	U	11/19/02
[redacted]					
E070GW001	070GW00101	24.2	µg/L	J	04/25/96
E070GW001	070GW00102	36	µg/L	J	07/29/96
E070GW001	070GW00103	2.1	µg/L	U	12/03/96
E070GW001	070GW00104	36.9	µg/L	J	02/18/97
E070GW001	070GW001M4	4.79	µg/L	U	07/10/02
E070GW001	070GW001M5	4.79	µg/L	U	11/19/02
[redacted]					

µg/L = micrograms per liter

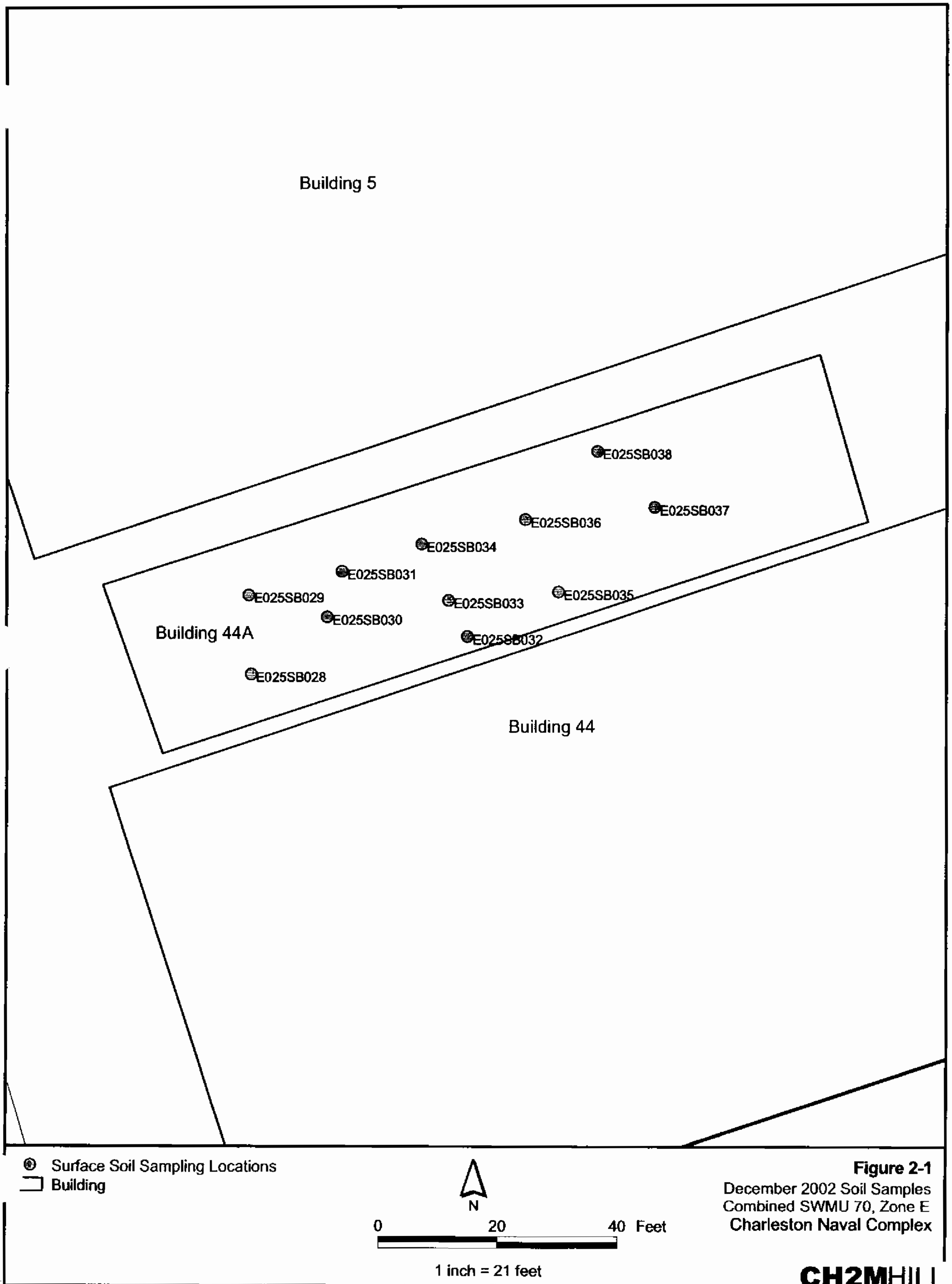


Figure 2-1
December 2002 Soil Samples
Combined SWMU 70, Zone E
Charleston Naval Complex

3.0 Site Hydrogeology and Nature and Extent of Contamination

This section summarizes results of RFI and post-RFI investigations regarding site hydrogeology, hydrology, and nature and extent of contamination.

3.1 Site Hydrogeology

The hydrogeology for Zone E was discussed in detail in the *Zone E RFI Report, Revision 0* (EnSafe, 1997). That discussion is summarized in this section.

The hydrogeology in Zone E is complex due to several factors:

- There is variable geologic lithology horizontally and vertically;
- The Cooper River, which lies to its east and serves as a groundwater discharge zone, is tidally influenced;
- A quay wall of sheet pilings and concrete that lies along the waterfront serves as a partial hydraulic barrier; and
- The shallow subsurface has been heavily disturbed by many anthropogenic activities related to industrial work, such as utilities, non-native fill material, support pilings, railroad lines, and crane rails.

3.1.1 Lithology

In the Combined SWMU 70 area, there are two stratigraphic units: the Wando Formation and the Ashley Formation. Overlying the Wando Formation are fill materials placed by anthropogenic activities. Geologic maps and cross sections through Zone E are presented in the *Zone E RFI Report, Revision 0.*

Ashley Formation

The Ashley Formation serves as a regional confining unit for the shallow aquifer and consists of a clayey, dense, calcareous silt. In the Combined SWMU 70 area, the top of the formation increases with depth to the north. The average elevation of the top of the Ashley Formation in Zone E is –24 ft mean sea level (msl). Figure A-1 in Appendix A shows the top of the Ashley elevation contours for the Combined SWMU 70 vicinity.

Wando Formation

The Wando Formation, which overlies the Ashley Formation, is composed of repeating sequences of back barrier clayey sand and clay deposits, barrier island sand deposits, and near shore shelf-sand deposits corresponding to three depositional periods. The thickness of the formation decreases to the south. In the Combined SMWU 70 area, the sands of the Wando Formation decrease in areal extent with depth. The clay deposits are typically thin and discontinuous, allowing for interconnection of sands at various depths. The clays within the formation serve as semi-confining layers between the shallow and deep groundwater zones.

On the western edge of the Combined SWMU 70 area, the Wando Formation extends to a depth of approximately 24 feet below land surface (ft bls) and consists of three layers: an upper sand unit, an interbedded sand and clay unit, and a lower sand unit.

On the eastern edge of the Combined SMWU 70 area, approaching the Cooper River, the Wando Formation extends to a depth of approximately 26 ft bls and consists of two layers: a clay unit and a sand unit.

Fill Materials

Due to the extensive surface soil disturbance at NAVBASE during its operational history, approximately the upper 5 feet of the subsurface at Zone E is typically a mixture of artificial fill and native sediments. In the Combined SMWU 70 area, the Wando Formation is overlain by a fill sand, which is typically very fine to fine-grained, and by Run of Crusher, which consists of a gravel in a clayey silt and sand matrix, typically used for subgrade in construction.

3.1.2 Hydrology

The Cooper River lies to the east of Zone E and serves as a groundwater discharge area. Its tidal influences are reflected to varying degrees up to 300 feet from the waterfront; Combined SMWU 70 is approximately 1,300 feet from the Cooper River. However, where stormwater or sewer lines have been installed, its influence may reach further inland. A tidal study preformed at Zone E determined that, in general, groundwater levels increase slightly between high and low tides.

The surficial aquifer extends from the water table to the top of the confining unit or the Ashley Formation. The saturated thickness of the aquifer in the Combined SWMU 70 area is approximately 27 feet. Groundwater levels were measured at Zone E during the RFI and in May 2002. Figures A-2 and A-3 present groundwater contours for the shallow and deep zones of the surficial aquifer, respectively (May 2002). These groundwater levels are approximately 1 foot lower than those presented in the RFI report, possibly due to drought conditions currently present in the southeast.

In the shallow groundwater zone, a groundwater divide exists in the Combined SWMU 70 area. This divide occurs approximately at the contact of the Wando sand (Qs) and the Wando clay (Qc), as presented in Figure 2-3a of the *Zone E RFI Report, Revision 0* and included in Appendix A. Groundwater to the east of the divide flows primarily to the east, towards a groundwater depression, just west of the Cooper River. Groundwater to the west of the divide primarily flows to the west and may flow eventually southwest toward the groundwater depression at SWMU 559. These depressions are likely caused by inward leaking sewers at AOC 559, located approximately 500 feet southwest of Combined SWMU 70.

Similar to the shallow zone, a groundwater divide also exists in the deep groundwater zone in the Combined SMWU 70 area. This divide may correspond to where the interbedded clay and sand unit of the Wando Formation pinch out at Zone E. Groundwater to the east of the divide flows primarily to the east-southeast towards the Cooper River and groundwater to the west of the divide flows primarily to the west-southwest and may eventually flow toward the depression at SWMU 559.

Based on the May 2002 data, the hydraulic gradient for flow in the shallow zone on both sides of the divide is approximately 0.001 feet per foot (ft/ft). In the deep zone the gradient is approximately 0.002 ft/ft. The small hydraulic gradients indicate that the groundwater velocity in the vicinity of Combined SMWU 70 may be extremely low. Such a conclusion would be consistent with the observation that groundwater contamination has not migrated a significant distance from the SWMU 70 source areas.

The vertical gradient measured at well cluster E070GW001 and E070GW01D (0.0097 ft/ft) in May 2002 indicates a slight upward vertical flow at Combined SWMU 70. Upward vertical flow at the CNC generally gets stronger closer to the Cooper River, except in localized areas that are influenced by man-made recharge or discharge, such as leaking water lines or sewer lines. Various geologic tests, including slug tests (October 1996), a pumping test at Combined SWMU 70 (April/May 1997), and specific capacity tests (November 1996), were performed at Zone E to estimate hydraulic conductivity at the site. The work was completed by the Navy/EnSafe team and was reported in the *Zone E RFI Report, Revision 0* (EnSafe, 1997). The average effective hydraulic conductivity was reported at 120 ft/day for the fill sand, 0.84 ft/day for the Wando clay, 11 ft/day for the upper sand of the Wando Formation, and 3.8 ft/day for the lower sand of the Wando Formation.

Assuming an effective porosity of 0.3, a groundwater flow (seepage) velocity of 26.8 and 9.2 ft/year can be calculated for the upper and lower sands, respectively, of the Wando Formation.

3.2 Contamination Assessment Summary

The information presented in this section discusses the extent of COCs in soil and groundwater. The refined list of COCs is presented in Section 2.3.

3.2.1 Soil COCs for Combined SWMU 70

The following COCs were identified for soil:

- Hexavalent chromium – due to leachability;
- Antimony – due to leachability;
- BEQs – due to exceedance of background values; and
- PCE, methylene chloride, and thallium were COCs in soil based on unrestricted land use at the site (i.e., if the existing pavement was removed). These constituents were in the SWMU 25 area but were not targeted in the December 2002 sampling event.

Figure 3-1 shows sample locations where COCs exceeded the unrestricted land use scenario (i.e., the unpaved scenario).

3.2.2 Groundwater COCs for Combined SWMU 70

Antimony, hexavalent chromium, cadmium, PCE, TCE, and vinyl chloride were identified as COCs in groundwater at Combined SWMU 70 in the RFI Report Addendum. Figure 3-2 shows the distribution of chromium, hexavalent chromium, antimony, and cadmium in groundwater at Combined SWMU 70, as reported in the CMS Work Plan. Likewise, Figure 3-3 shows the distribution of PCE, TCE, and vinyl chloride in groundwater at Combined SWMU 70, as reported in the CMS Work Plan. In April 2001, vertical profile samples of groundwater were collected and analyzed for hexavalent chromium and cadmium. Figures 3-4, 3-5, and 3-6 show the distribution of hexavalent chromium and cadmium in groundwater, as reported by the vertical profile results. The three figures represent three different elevation zones in the groundwater (shallow, intermediate, and deep).

Inspection of Figures 3-2 through 3-6 shows general delineation of contaminants, with the exception of hexavalent chromium to the west. For this reason, groundwater alternatives developed for Combined SWMU 70 will include the two new shallow monitoring wells. The proposed location of these wells is presented in Figure 3-7.

3.3 Current Conditions – Pilot Study Status

The details of this pilot study implementation and initial data results are presented in *RFI Report Addendum and CMS Work Plan*. Table 3-1 presents results of key performance parameters over time. The data, current through May 2003, are discussed in the following:

- E070GW001 – Hexavalent chromium at this well has been reduced from 2,070 micrograms per liter (μg/L) to 333 μg/L (84-percent reduction). Water quality indicators show no significant changes in geochemical parameters between pre-treatment (April 2001) and post-treatment conditions, yet substantive hexavalent chromium reduction is observed.
- E070GW002 – Hexavalent chromium levels have never exceeded the MCL.
- E070GW01D - Hexavalent chromium at this well has been reduced from 31,000 μg/L to 8,180 μg/L (74-percent reduction). Water quality indicators show oxidation reduction potential (ORP) beginning to rise toward pre-treatment conditions (April 2001). However, substantive hydrogen gas is still being produced at this location (32,000 nM), indicating the ZVI is active.
- E070GW005 – This well was installed after the emplacement of ZVI was complete. The actual pre-treatment concentration of hexavalent chromium at this location is unknown. Hexavalent chromium has been reduced from 4,300 μg/L (in July 2002) to 7.89 μg/L (99.8-percent reduction) during this post-treatment monitoring period.
- E070GW05D - This well was installed after the emplacement of ZVI was complete. The actual pre-treatment concentration of hexavalent chromium at this location is unknown. Hexavalent chromium has been reduced from 1,350 μg/L (in July 2002) to 5.84 μg/L (99.6-percent reduction) during this post-treatment monitoring period.
- E070GW006 - This well was installed after the emplacement of ZVI was complete. The actual pre-treatment concentration of hexavalent chromium at this location is unknown. Hexavalent chromium has been reduced from 4,030 μg/L (in July 2002) to 239 μg/L (94-percent reduction) during this post-treatment monitoring period. Hydrogen gas production has decreased over time.
- E070GW06D - This well was installed after the emplacement of ZVI was complete. The actual pre-treatment concentration of hexavalent chromium at this location is unknown. Hexavalent chromium has increased from 16 μg/L (in July 2002) to 458 μg/L. The reason for this increase is unknown. However, inspection of the data reported in Table 2-1 indicates up-and-down fluctuations in some hexavalent chromium data. The results reported at this time will have to be further evaluated with additional sampling events

to determine the relative significance of this apparent increase in hexavalent chromium concentrations.

The above data show that in situ chemical reduction using ZVI was effective in reducing hexavalent chromium concentrations, as of the May 2003 sampling event. Significant decreases in hexavalent chromium have been reported, since the ZVI was emplaced in January 2002.

TABLE 3-1
Results at Monitoring Wells Over Time
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

[redacted]							
[redacted]	6.12	5.99	5.6	5.8	5.77	6.3	5.83
[redacted]	17.9	18.5	21	21.8	25.18	23	21.1
[redacted]	64	0	15		0	89	-4.9
[redacted]	5.4	1.13	1.14	0.84	0.67	5.77	6.03
[redacted]	192	162	201	176	172	193	188
[redacted]	392	362	401	376	372	393	388
[redacted]	15	0.25	0.2	0.19	0.177	1.66	0.218
[redacted]	2,580	1,650	NS	1,680	2,000	289	343
[redacted]	2,070	770	NS	1,450	1,420	358	333
[redacted]	1.2	NS	0.52	NS	3.9	140	12
[redacted]	3.2	NS	0.03	NS	2.1	0.46	NS

[redacted]							
[redacted]	5.96	5.75	5.12	5.38	7.29	2.39	NS
[redacted]	18.7	19.2	21.4	22.6	25.72	25	NS
[redacted]	31	0	3	3	26	3.7	NS
[redacted]	2.3	0.43	0.24	0.1	0.19	2.83	NS
[redacted]	201	170	213	182	-1	229	NS
[redacted]	401	370	413	382	199	429	NS
[redacted]	14	0.19	0.15	0.19	0.168	1.77	NS
[redacted]	19.8	26.7	NS	21.6	16.4	41.9	NS
[redacted]	0.04	0.025	NS	0.27	54	28	NS
[redacted]	NS	NS	0.36	NS	35	0.75	NS
[redacted]	NS	NS	8.6	NS	9.8	0.74	NS

[redacted]							
[redacted]	6.07	7.25	6.46	6.4	8.84	6.45	5.85
[redacted]	20.9	21.9	22.2	22.6	22.8	23	21.6
[redacted]	110	26.1	60	46	250	0	-10
[redacted]	0.4	0	0	0	0	0.3	1.58
[redacted]	216	123	143	144	-129	68	151

TABLE 3-1
Results at Monitoring Wells Over Time
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

[redacted]	416	323	343	344	71	268	351
	57	0.82	0.82	0.8	0.812	0.875	0.714
	30,600	12,200	NS	14,100	12,500	11,500	12,500
	31,000	1,350	NS	14,800	9,200	15,300	8,180
	14	NS	29,000	NS	43,000	31,000	32,000
	630	NS	32	NS	52	110	NS
[redacted]							
	NS	NS	NS	NS	6.07	5.94	5.06
	NS	NS	NS	NS	22.3	23	20.4
	NS	NS	NS	NS	1.03	0	0
	NS	NS	NS	NS	0	1.38	1.43
	NS	NS	NS	NS	-26	112	93
	NS	NS	NS	NS	174	312	293
	NS	NS	NS	NS	0.16	0.162	0.13
	NS	NS	NS	NS	2,930	183	284
	NS	NS	NS	NS	4,300	6	7.89
	NS	NS	NS	NS	73,000	490	3.9
	NS	NS	NS	NS	5.7	10	NS
[redacted]							
	NS	NS	NS	NS	7.34	6.55	5.63
	NS	NS	NS	NS	22.1	23	21.7
	NS	NS	NS	NS	30	0	4.1
	NS	NS	NS	NS	0	0.19	1.29
	NS	NS	NS	NS	-90	36	-12
	NS	NS	NS	NS	110	236	
	NS	NS	NS	NS	0.55	0.463	0.285
	NS	NS	NS	NS	1,950	987	2,820
	NS	NS	NS	NS	1,350	140	5.84
	NS	NS	NS	NS	39,000	28,000	67
	NS	NS	NS	NS	59	460	NS

TABLE 3-1
Results at Monitoring Wells Over Time
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

[redacted]							
[redacted]	NS	NS	NS	NS	6.03	5.92	5.17
	NS	NS	NS	NS	22.7	24	21.2
	NS	NS	NS	NS	23.5	0	5.3
	NS	NS	NS	NS	0	0.3	1.29
	NS	NS	NS	NS	32	115	80
	NS	NS	NS	NS	232	315	280
	NS	NS	NS	NS	0.232	0.177	0.157
	NS	NS	NS	NS	6,850	1,390	953
	NS	NS	NS	NS	4,030	2,500	239
	NS	NS	NS	NS	33,000	740	250
	NS	NS	NS	NS	37	330	NS

[redacted]							
[redacted]	NS	NS	NS	NS	9.17	6.47	5.89
	NS	NS	NS	NS	22.5	23	21.9
	NS	NS	NS	NS	125	107	290
	NS	NS	NS	NS	0	0.26	1.27
	NS	NS	NS	NS	-222	26	-76
	NS	NS	NS	NS	-22	226	124
	NS	NS	NS	NS	0.323	0.396	0.329
	NS	NS	NS	NS	504	3.2	3,000
	NS	NS	NS	NS	16	21	458
	NS	NS	NS	NS	64,000	460	1,700
	NS	NS	NS	NS	840	1800	NS

NS = Not Sampled

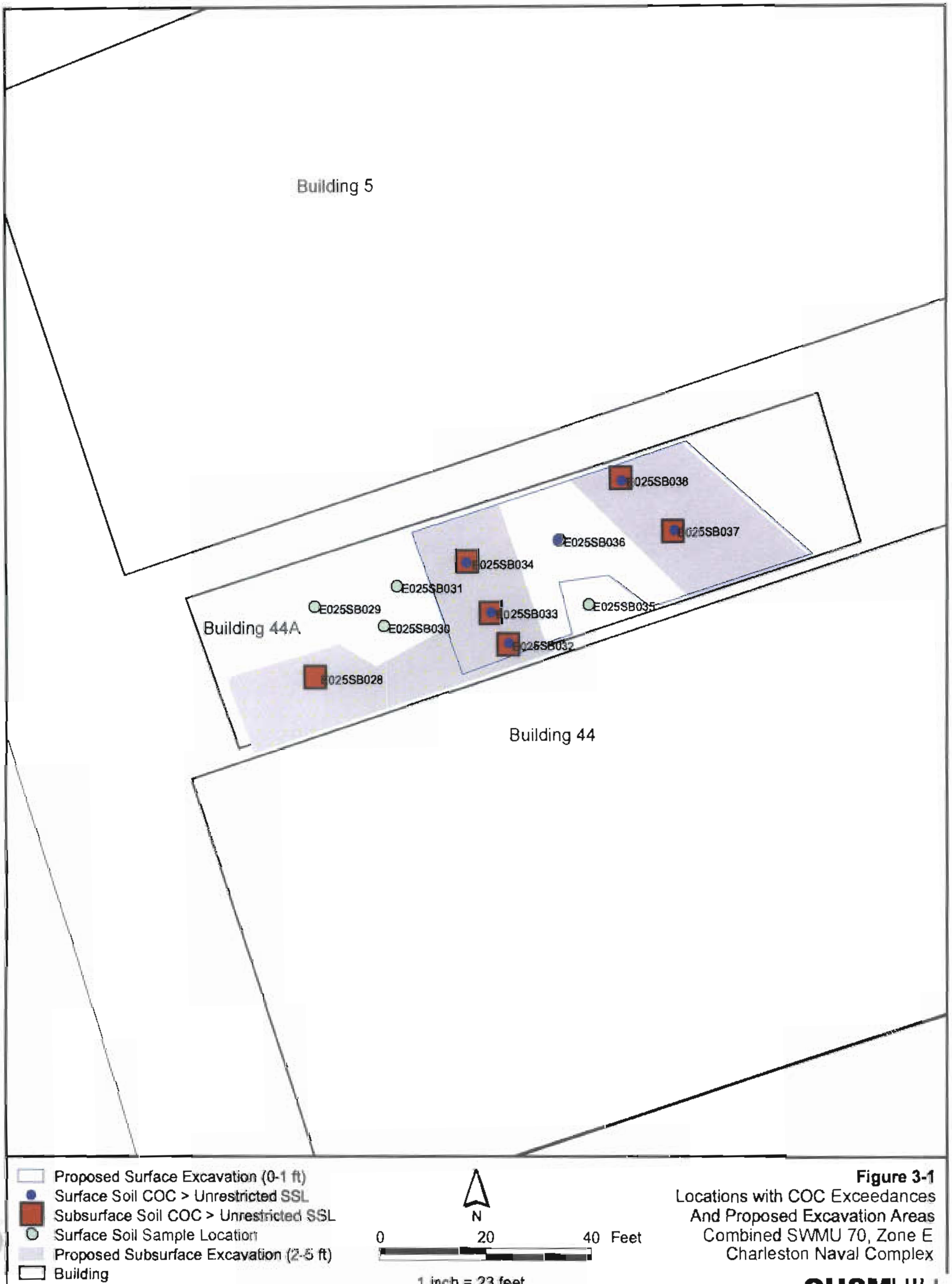
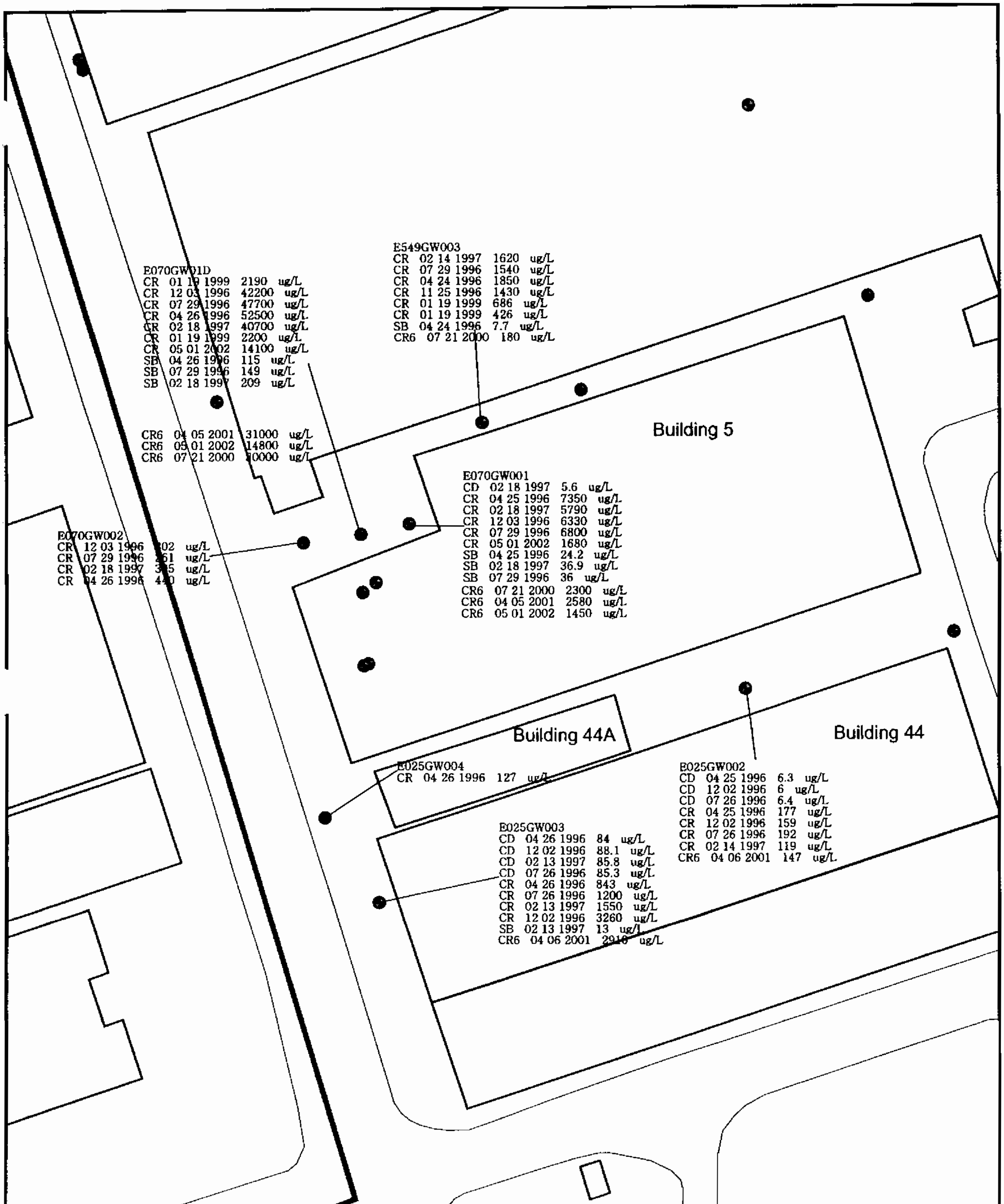


Figure 3-1
Locations with COC Exceedances
And Proposed Excavation Areas
Combined SWMU 70, Zone E
Charleston Naval Complex

File Path: c:\18gis\projects\zone_e\combined swmu 70\apr\rfire_cmswp.apr, Date: 10 Jul 2003 15:36, User: PIFAVARA, EGIS: Charleston Naval Complex - Figure 3-1 Locations with COCs > Unrestricted Use



- Groundwater Well
- AOC Boundary
- SWMU Boundary
- Building
- Zone Boundary

N

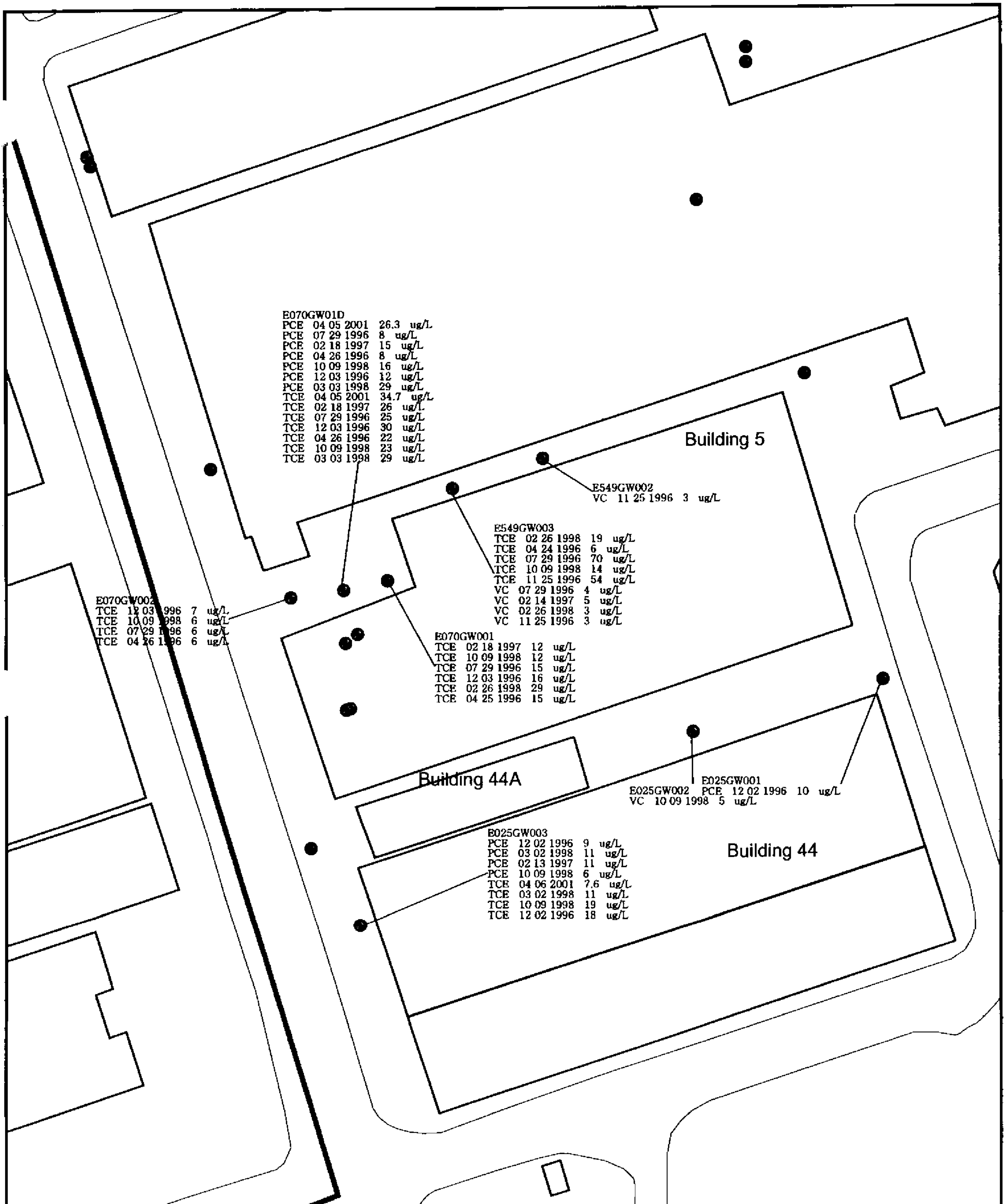
0 50 100 Feet

1 inch = 73 feet

Figure 3-2
Exceedances of Groundwater MCLs for Antimony, Hexav. Chromium, Total Chromium and Cadmium
Combined SWMU 70, Zone E
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 25 Jul 2002 15:42, User: PFAVARA, RFIRA_CMSWP: Figure 7-5 Sb, Cr, Cr6, and Cd MCL Exceedances



Groundwater Well
AOC Boundary
SWMU Boundary
Building
Zone Boundary

N

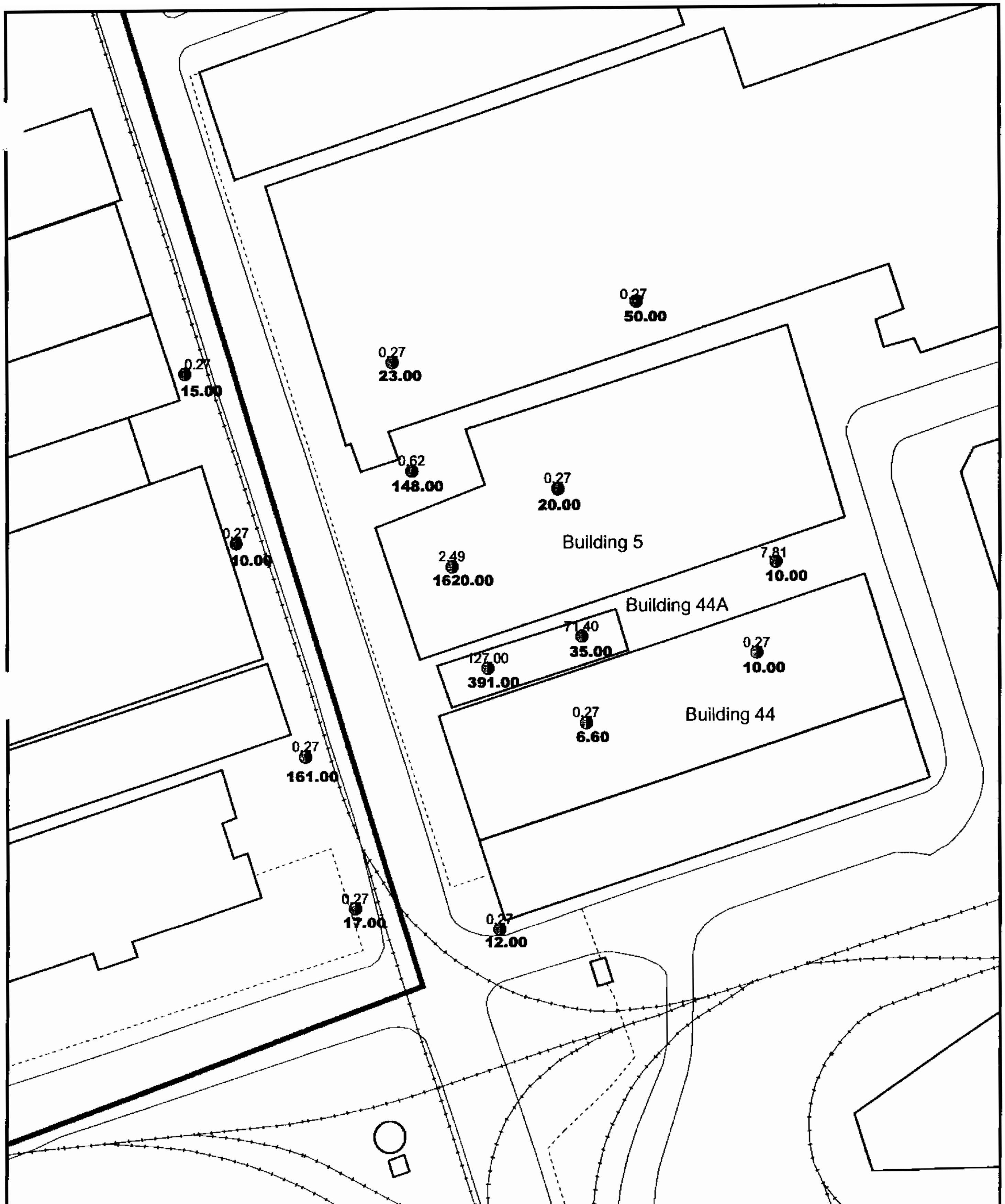
0 60 120 Feet

1 inch = 73 feet

Figure 3-3
Exceedances of Groundwater MCLs for PCE, TCE and VC
Combined SWMU 70, Zone E
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 25 Jul 2002 15:20, User: PFAVARA, RFIRA_CMSWP: Figure 7-6 PCE, TCE, and VC Exceeding MCLS



Cd and Cr6 (ppb) 0 - + 2 ft msl (see note)
AOC Boundary
SWMU Boundary
Buildings

Note: Bold = Cr6, Non-Bold = Cd
Detection limit for Cd = 0.27 ppb

N

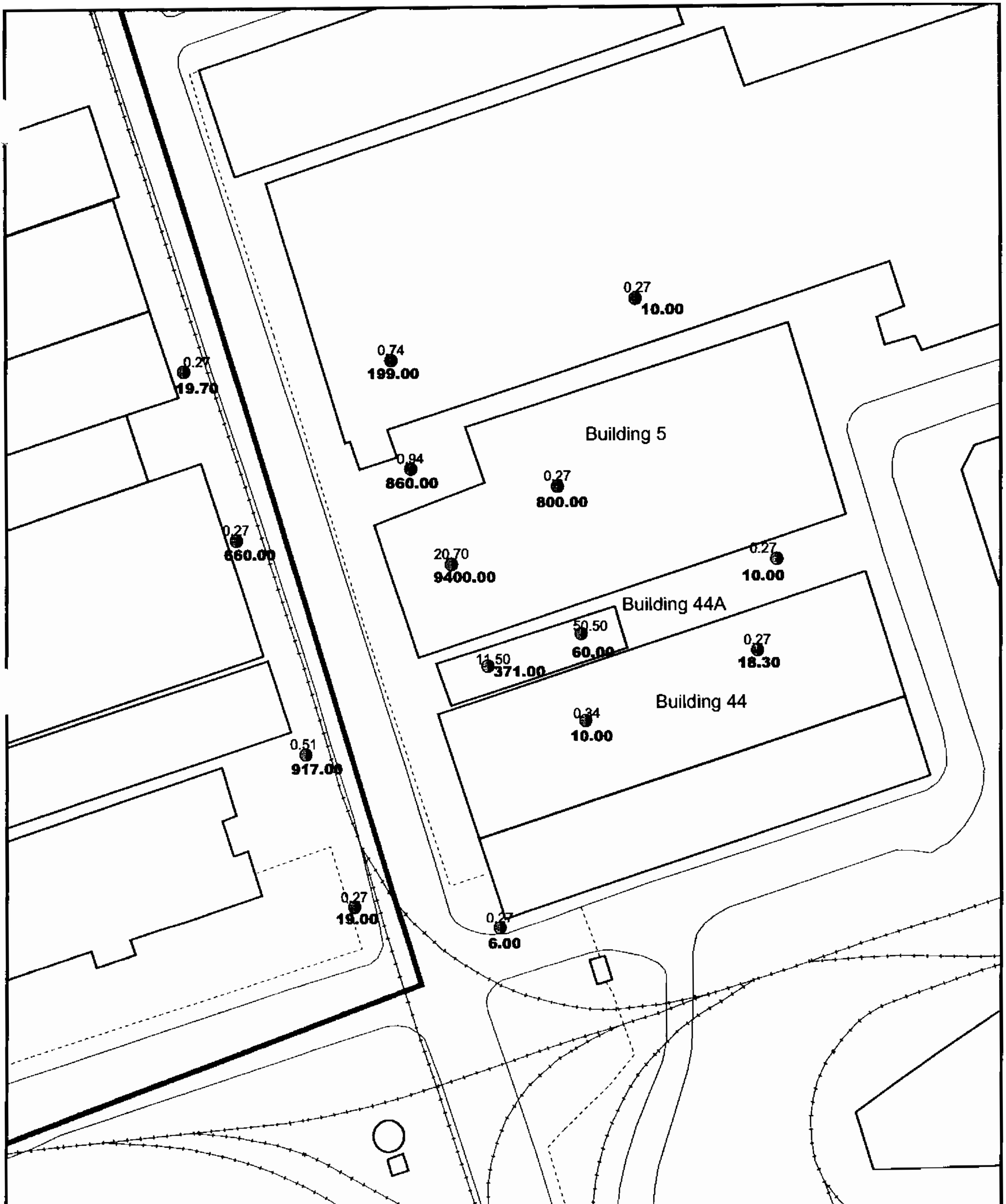
0 70 140 Feet

1 inch = 88 feet

Figure 3-4
Cadmium and Hexav. Chromium in Groundwater
0 to +2 ft msl
Combined SWMU 70, Zone E
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 23 Jul 2002 17:20, User: PFAVARA, RFIRA_CSMWP: Figure 7-5 Cd and Cr6 in Groundwater



● Cd and Cr6 (ppb) 0 to -15 ft msl (see note)
AOC Boundary
SWMU Boundary
Buildings

Note: Bold = Cr6; Non-Bold = Cd

Detection limit for Cd = 0.27 ppb

N

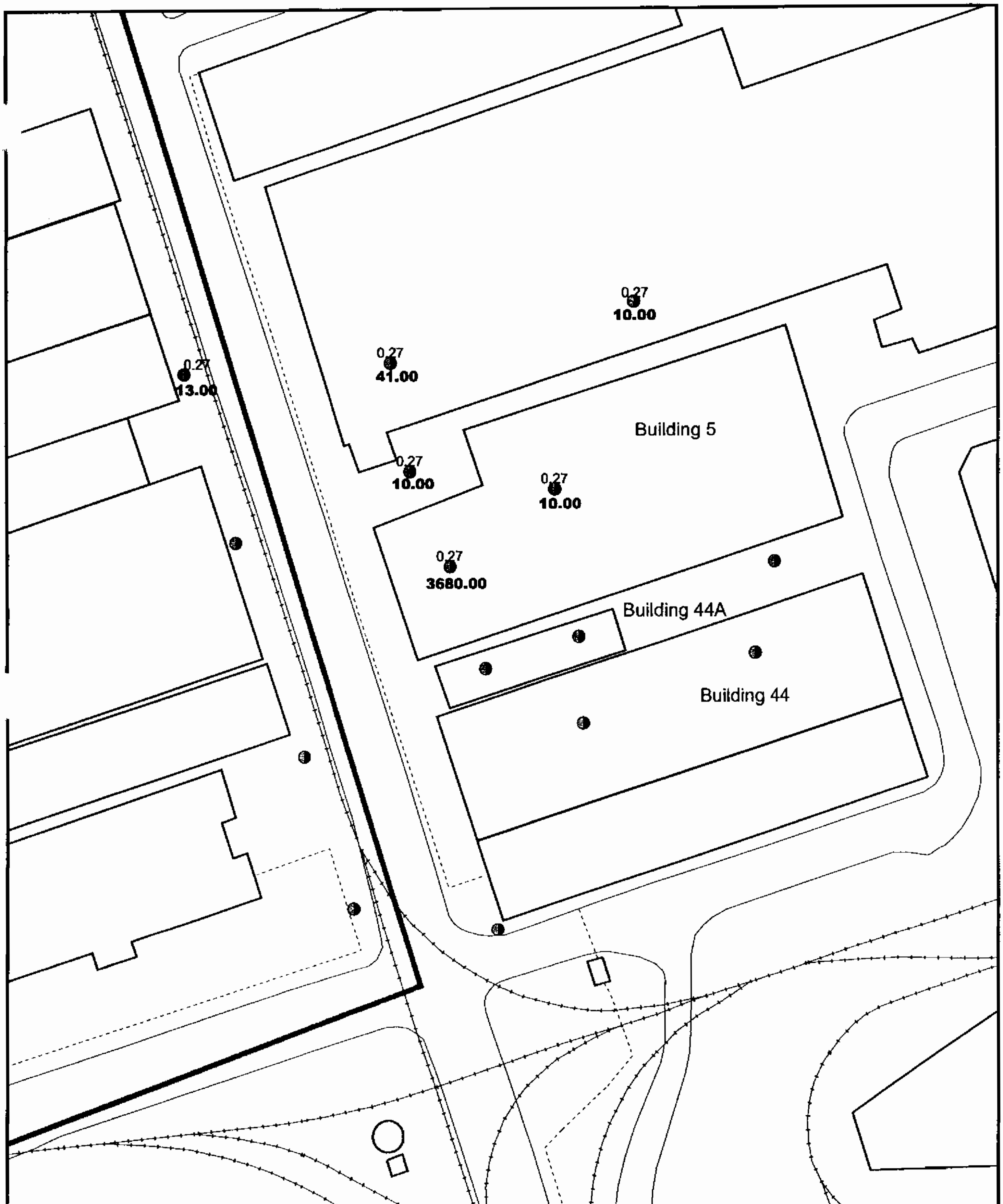
0 70 140 Feet

1 inch = 88 feet

Figure 3-5
Cadmium and Hexav. Chromium in Groundwater
0 to -15 ft msl
Combined SWMU 70, Zone E
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 23 Jul 2002 17:39, User: PFAVARA, RFIRA_CMSWP: Figure 7-6 Cd and Cr6 in Groundwater



Cd and Cr6 (ppb) -16 to 24 ft msl (see note)
AOC Boundary
SWMU Boundary
Buildings

Note: Bold = Cr6, Non-Bold = Cd
Detection limit for Cd = 0.27 ppb

N

0 70 140 Feet

1 inch = 88 feet

Figure 3-6
Cadmium and Hexav. Chromium in Groundwater
-16 to -24 ft msl
Combined SWMU 70, Zone E
Charleston Naval Complex

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File Path: c:\18gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 23 Jul 2002 17:35, User: PFAVARA, RFIRA_CMSWP: Figure 7-7 Cd and Cr6 in Groundwater

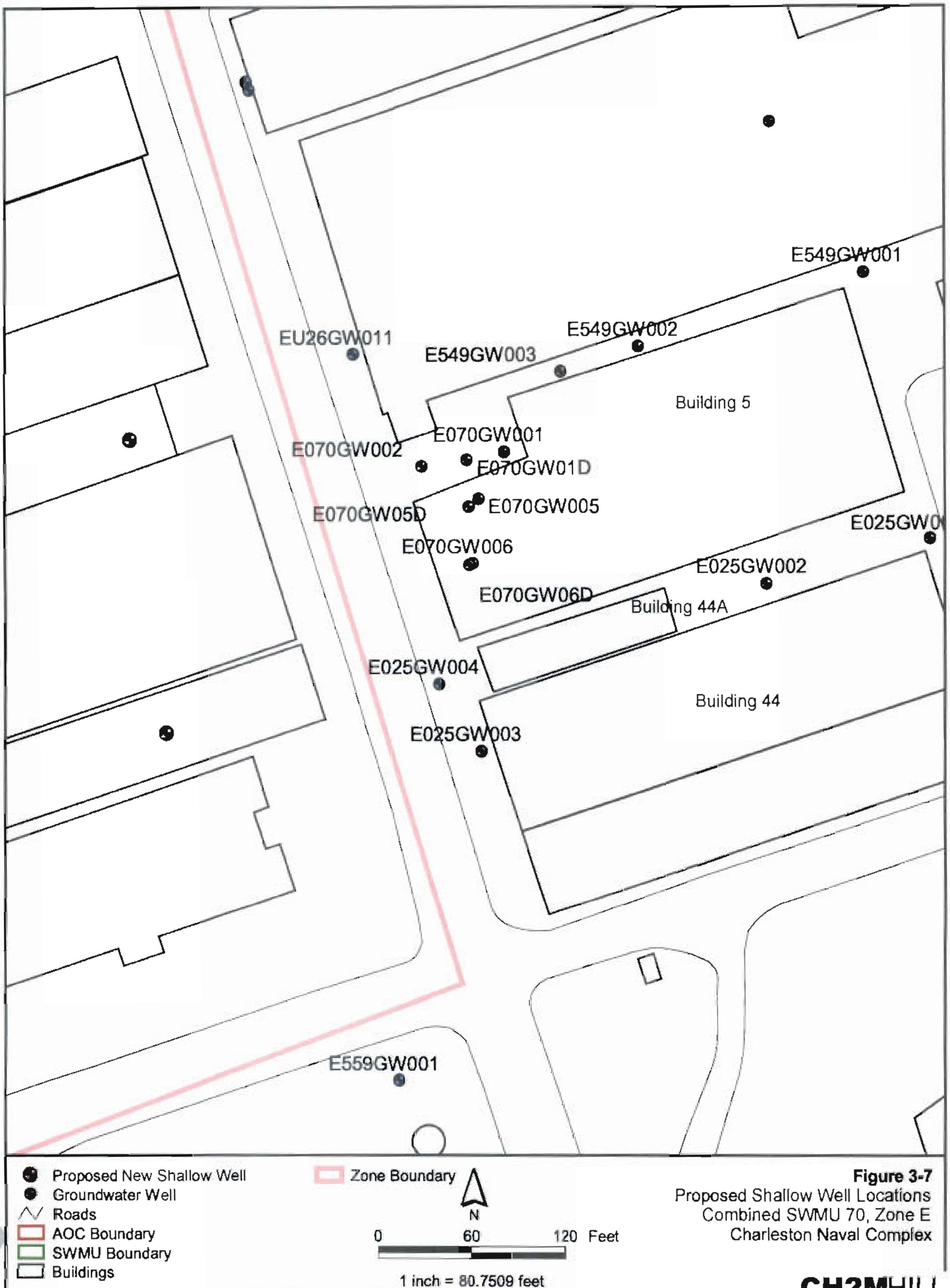

Figure 3-7
Proposed Shallow Well Locations
Combined SWMU 70, Zone E
Charleston Naval Complex

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File Path: c:\18gis\projects\zone_e\combined swmu 70\apr\rfira_cmswp.apr, Date: 10 Jul 2003 16:18, User: PFAVARA, EGIS: Charleston Naval Complex - Figure 3-2 Proposed Intermediate Depth Wells

Section 4.0

4.0 RAOs, Proposed MCSs, and Alternative Evaluation Criteria

This section discusses the RAOs of this CMS and presents MCSs for COCs. Once the RAOs and MCSs are established, candidate remedial technologies and alternatives can be developed to meet these objectives. This section also identifies the evaluation criteria used in comparing the CMS alternatives.

4.1 Remedial Action Objectives

RAOs are environmental medium-specific goals that are created to protect human health and the environment by preventing or reducing exposures under current and future land use conditions.

The RAOs identified for soil at Combined SWMU 70 are:

1) Protect industrial receptors from contact with contaminated soils with COC concentrations that could cause unacceptable systemic or carcinogenic effects; and

2) Protect groundwater from leachability of contaminated soils with COC concentrations that potentially threaten groundwater quality.

The RAOs identified for the groundwater at Combined SWMU 70 are:

1) To prevent ingestion and direct/dermal contact with groundwater having unacceptable carcinogenic or non-carcinogenic risk, and

2) To restore the aquifer to beneficial use.

4.2 Remedial Goal Options and Proposed Media Cleanup Standards

4.2.1 RGOs and MCSs for Soil

The matrix in Table 2-3 presents a summary of the COCs identified by medium and exposure pathway. BEQs were the only COC identified for surface soil, based solely on the exposure pathway to human receptors (via exceeding background, which is higher than risk-based values); no direct exposure-based human health COCs were identified for subsurface soils.

Table 4-1 presents RGOs and MCSs for COCs at Combined SWMU 70.

4.2.2 MCSs for Groundwater

Hexavalent chromium, cadmium, PCE, TCE, and vinyl chloride were identified as COCs in groundwater at Combined SWMU 70. MCLs are the primary MCSs for groundwater RGOs. Table 4-2 provides a list of the groundwater MCS values.

4.3 Evaluation Criteria

According to the RCRA permit issued by SCDHEC (SCDHEC, 1998), the alternatives were evaluated with the following five criteria:

1. Protect human health and the environment.
2. Attain MCSs, which will generally be the RGOs.
3. Control the source of releases to minimize future releases that may pose a threat to human health and the environment.
4. Comply with applicable standards for the management of wastes generated by remedial activities.
5. Other factors include (a) long-term reliability and effectiveness; (b) reduction in toxicity, mobility, or volume of wastes; (c) short-term effectiveness; (d) implementability; and (e) cost.

Each of the five criteria is defined in more detail below.

4.3.1 Protect Human Health and the Environment

The alternatives were evaluated on the basis of their ability to protect human health and the environment. The ability of an alternative to achieve this criterion may or may not be independent of its ability to achieve the other standards. For example, an alternative may be protective of human health, but may not be able to attain the MCSs if the MCSs are not directly tied to protecting human health.

4.3.2 Attain MCSs

The alternatives were evaluated on the basis of their ability to achieve the RGOs defined in the CMS Work Plan for Combined SWMU 70 (CH2M-Jones, 2002a). Another aspect of this criterion is the time frame to achieve the RGOs.

4.3.3 Control the Source of Releases

This standard deals with the control of releases of contamination from the source (the area in which the contamination originated).

4.3.4 Comply with Applicable Standards for Management of Wastes

This criterion deals with the management of wastes derived from implementing the alternatives, for example, treatment or disposal of well cuttings, contaminated groundwater, or excavated material from a source area.

4.3.5 Other Factors

Five other factors are to be considered if an alternative is found to meet the four criteria described above. These other factors are as follows:

a. Long-term reliability and effectiveness

   The various alternatives will be evaluated on the basis of their reliability, and the potential impact should the alternative fail. In other words, a qualitative assessment was made as to the chance of the alternative's failing and the consequences of that failure.

b. Reduction in the toxicity, mobility, or volume of wastes

   Alternatives with technologies that reduce the toxicity, mobility, or volume of the contamination were generally favored over those that do not. Consequently, a qualitative assessment of this factor was performed for each alternative.

c. Short-term effectiveness

   Alternatives were evaluated on the basis of the risk they create during the implementation of the remedy. Factors that may be considered include fire, explosion, and exposure of workers to hazardous substances.

d. Implementatiblity

   The alternatives were evaluated for their implementability by considering any difficulties associated with conducting the alternatives (such as the construction disturbances they may create), operation of the alternatives, and the availability of equipment and resources to implement the technologies comprising the alternatives.

e. Cost

A net present value of each alternative was developed. These cost estimates were used for the relative evaluation of the alternatives, not to bid or budget the work. The estimates were based on information available at the time of the CMS and on a conceptual design of the alternative. They are "order-of-magnitude" estimates with a generally expected accuracy of -30 percent to +50 percent for the scope of action described for each alternative. The estimates were categorized into capital costs and operations and maintenance costs for each alternative.

TABLE 4-1
MCSs for Surface and Subsurface Soils at SWMU 25
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Constituent	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)
BEQ	1.30	1.40
Antimony – Paved	4.25	4.25
Antimony – Unpaved	0.70	0.70
Cr(VI) – Paved	56	56
Cr(VI) – Unpaved	9	9
PCE – Paved	N/A	.05
PCE – Unpaved	N/A	0.003
Methylene Chloride – Paved	0.02	0.02
Methylene Chloride – Unpaved	0.003	0.003
Thallium – Paved	N/A	5.95
Thallium – Unpaved	N/A	0.35

Note: S is with respect to average concentration for exposure area.

TABLE 4-2
Groundwater MCSs/RGOs for Combined SWMU 70
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Chemical	Range of Detected Concentrations (µg/L)	EPC	Background Range of Concentrations (µg/L)	MCL	RGO for Noncarcinogenic Health Hazards				Proposed MCS	Explanation
					HI =	0.1	1.0	3.0		
Cadmium	0.4 - 88	17	1.4	5.0		3.7	37	111	5.0	MCL is proposed goal
Chromium VI	147 - 31,000	9,732	NA	NA		11	111	333	100	Noncarcinogen via ingestion, same as MCL
Chromium, total	1.6 - 52,500	8,524	0.8 - 31	100		5,500	55,000	165,000	100	
					ELCR	10-6	10-5	10-4		
PCE	1.0 - 26	5.6	NA	5		1.1	11	110	5.0	MCL is proposed goal
TCE	0.26 - 70	13	NA	5		1.6	16	160	5.0	MCL is proposed goal
Vinyl Chloride	0.7 - 5.0	4.0	NA	2		0.041	0.41	4.1	2.0	MCL is proposed goal

All units are in micrograms per liter (µg/L).

ELCR – Excess Lifetime Cancer Risk
EPC – Exposure Point Concentration (calculated as UCL_{95})

5.0 Description of Candidate Corrective Measure Alternatives

This section presents the identification and description of candidate corrective measure alternatives for soil in groundwater.

5.1 Description of Alternatives

5.1.1 Soil Corrective Measure Alternatives

A soil corrective measure is intended to mitigate residual source areas of COCs that could continue to release COCs in soil to the groundwater, via infiltration, at concentrations that could negatively impact groundwater quality.

The corrective measure alternative developed for soil at Combined SWMU 70 is:

- Alternative S1 – Capping with land use controls (LUCs)
- Alternative S2 – Soil Excavation and Offsite Disposal

A comparison evaluation of these alternatives is provided in Section 6.0 and in Table 6-1. A description of each alternative is presented below. Additional alternatives were not developed because the current cap is adequate for meeting RAOs and MCSs.

Alternative S1 – Capping with LUCs

This technology involves installation of a barrier over contaminated soils. The barrier would significantly minimize or prevent further infiltration of water into contaminated soils and result in significant decrease in leachability of contaminants from soils. The suitability of the existing asphalt cap, which was installed after the IM completed in 1998, will be evaluated. No additional capping, aside from that asphalt structure currently in place, was considered with this alternative.

Alternative S2 – Soil Excavation and Offsite Disposal

This alternative will remove contaminated soil in areas that exceed the MCS established in Section 4.0 (see Figure 3-1). One surface area that is approximately 1,300 square feet (ft^2) requires excavation. . Soils in this area will be excavated to 1 foot in depth. Assuming a 20-percent excavation swell factor, this will result in approximately 37 cubic yards (y^3) of soil that will require disposal. This volume also includes asphalt structure that will be removed.

Two subsurface areas require excavation, one approximately 340 ft^2 and the other approximately 572 ft^2. Assuming a depth of excavation from 2 to 5 feet, and a 20-percent excavation swell factor, approximately 230 y^3 of soil will require disposal. With this alternative, approximately 2,100 ft^2 of existing asphalt will have to be removed and replaced.

Excavated soil would be transported to a permitted landfill facility for long-term disposal, and the excavation would be filled with clean fill from an offsite borrow source. Once the soil is removed, the site would be acceptable for unrestricted land use, with no long-term monitoring required. However, because the site is located in Zone E, there will continue to be LUCs that apply to the entire zone. These LUCs are expected to include restrictions of the property to non-residential activities.

Confirmation sampling would involve approximately 20 samples from various locations along the wall and floor of the excavation. If the excavation of the subsurface soil advances to the water table, floor samples will not be required. An equal amount of clean backfill will be required to fill in the excavated areas and of concrete or bituminous asphalt to replace the pavement.

5.1.2 Other Considerations

Coordination with the Redevelopment Authority (RDA) would be required for site restrictions during excavation and traffic control for the haul trucks. The potential for expansion of scope during confirmation testing is moderate. Thus, a 20-percent scope contingency is assumed.

5.1.3 Groundwater Corrective Measure Alternatives

A groundwater corrective measure is intended to mitigate residual "hot spots" of hexavalent chromium in groundwater. It is anticipated that COCs above MCSs outside this area will be attenuated over time. Hydraulic information available for the site indicates groundwater moves very slowly in the Combined SWMU 70 area.

The corrective measure alternative developed for soil at Combined SWMU 70 is:

- Alternative GW1 – In situ Chemical Reduction Using ZVI
- Alternative GW2 – Monitored Natural Attenuation

A comparison evaluation of these alternatives is provided in Section 6.0 and in Table 6-1. A description of each alternative is presented below.

Alternative GW1 – In Situ Chemical Reduction using ZVI

This technology involves utilization of ZVI to affect chemical reduction of hexavalent chromium in groundwater. The ZVI will function as an electron donor to be used in chemical-reduction reactions with hexavalent chromium. The desired result of ZVI emplacement is reduction of hexavalent chromium in groundwater. This alternative also involved installing two shallow depth wells to the west of Combined SWMU 70 (see Figure 4-1). These wells will help define the limits of the hexavalent chromium concentrations in excess of the MCL and be used to monitor changing conditions in the plume periphery as a result of upgradient reduction of hexavalent chromium. This alternative also involved monitoring COCs present above MCSs, albeit at low concentrations, outside the target treatment area. These constituents are expected to be attenuated over time.

This alternative will involve the installation of two intermediate-depth wells to the west of Combined SWMU 70 to monitor the migration of hexavalent chromium.

Alternative GW2 – MNA with LUCs

This alternative involves the implementation of MNA with LUCs. The LUCs will prevent human receptors from exposure to contaminated groundwater. The monitoring required to support an MNA alternative will provide data regarding migration of contaminants and can be used to assess potential future exposure should the plume migrate to an unanticipated area.

This alternative will involve the installation on two shallow monitoring wells to the west of Combined SWMU 70 to monitor the migration of hexavalent chromium.

For MNA to be effective with hexavalent chromium in groundwater, several factors should be observed, according to EPA. These factors are presented in Table 5-1, along with a current site status with respect to the factor.

Generally, conditions appear favorable for natural attenuation of hexavalent chromium at Combined SWMU 70. However, little data are available to determine the rate at which hexavalent chromium concentrations are being naturally reduced.

TABLE 5-1
Ideal Conditions for MNA of Cr(VI) and SWMU 70 Site Conditions
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Ideal MNA Conditions for Cr(VI)	Combined SWMU 70 Conditions
There are natural reductants present within the aquifer.	Ferrous iron is plentiful in the formation. However, there may be inadequate iron near E070GW01D, which has historically reported the highest concentrations of Cr(VI). However, Cr(VI) migrating from this area may be amendable to reduction with the ferrous iron present at the site.
The amount of hexavalent chromium and other reactive constituents do not exceed the capacity of the aquifer to reduce them.	There is adequate iron to support Cr(VI) reduction in the formation. The relative rate that this is occurring is not known.
The rate of hexavalent chromium reduction is greater than the rate of transport of the aqueous Cr(VI).	The status of this factor is unknown. Two new wells will be installed to the west of Combined SWMU 70 (see Figure 3-7) to assess this component.
The Cr(III) remains immobile.	The status of this factor is unknown. Most of the chromium reported at Combined SWMU 70 is in the Cr(VI) form. However, there are some instances where total chromium concentration is greater than Cr(VI), indicating some Cr(III) mobility.
There is no net oxidation of Cr(III) to Cr(VI).	Very rigorous conditions are required for Cr(III) to be oxidized to Cr(VI). These conditions are not anticipated in subsurface conditions.

6.0 Detailed Analysis of Alternatives

This section presents the detailed analysis of corrective measure alternatives for groundwater at Combined SWMU 70.

6.1 Alternative S1 – Capping with Land Use Controls

Alternative S1 involves maintenance of the current asphalt cap at Combined SWMU 70 area, specifically at SWMU 25. The cap will function to prevent infiltration of water through contaminated soils, thereby protecting groundwater from leachable levels of COCs that could threaten groundwater.

This alternative also includes LUCs. The LUCs will ensure that the asphalt cap is properly maintained and repaired, as required.

With this alternative, it has been assumed that a base-wide LUC Management Plan (LUCMP) will be developed for the CNC. The plan will allow for restrictions on the use of groundwater at Combined SWMU 70 and other areas, and it will be developed outside the scope of this CMS.

6.1.1 Protection of Human Health and the Environment

Alternative S1 would be effective at protecting human health because it would incorporate LUCs to maintain the existing asphalt cap at SWMU 25. The cap will prevent unacceptable levels of hexavalent chromium from leaching to groundwater.

6.1.2 Attain MCS

Alternative S1 can achieve the MCSs for the paved COCs, on a site average basis, and minimize infiltration into contaminated soils. The time to achieve MCSs would be instantaneous because the cap is already in place, as a result of the 1999 IM.

6.1.3 Control the Source of Releases

There are no ongoing sources of releases at Combined SWMU 70. The series of IMs conducted at the site have removed significant sources of contamination.

6.1.4 Compliance with Applicable Standards for the Management of Generated Wastes

Alternative S1 would not generate any wastes.

6.1.5 Other Factors (a) Long-term Reliability and Effectiveness

Alternative S1 would have adequate long-term reliability and effectiveness, provided that the asphalt cap is properly maintained and LUCs prevent penetration into the cap to a degree that would threaten its ability to minimize infiltration of water.

6.1.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

The mobility of contaminants is reduced with implementation of this alternative, as contaminants in the soil will have reduced mobility via infiltration. Toxicity and mass of contaminants in the soil are not altered with Alternative S1.

6.1.7 Other Factors (c) Short-term Effectiveness

Through the implementation of LUCs, Alternative S1 would have short-term effectiveness in minimizing transport of hexavalent chromium to groundwater. No significant short-term risks would be created using this alternative.

6.1.8 Other Factors (d) Implementability

Alternative S1 would be easily implemented since the cap has already been emplaced. This alternative only requires the implementation of LUCs and an appropriate monitoring program.

6.1.9 Other Factors (e) Cost

Alternative S1 has a present-value cost of $31,000 over a 20-year period. Detailed cost components are presented in Appendix C. Major components of this cost include annual inspection of the asphalt cap and annual reporting on cap integrity. The 20-year period is used only for the purpose of cost estimating. It is recognized that the cap would remain as long as necessary, which could be greater than 20 years.

6.2 Alternative S2: Soil Excavation and Offsite Disposal

The following assumptions were made for Alternative S2:

- One surface area and two subsurface areas will be excavated, as presented in Figure 3-1 and discussed in Section 5.1.1 under Alternative S2.
- A total of approximately 230 y^3 of soil (with swell factor and pavement) would be excavated for offsite disposal at a Subtitle D facility and replaced with clean backfill.
- Approximately 2,100 ft^2 of pavement would be removed/replaced.

- Confirmation testing will validate the extent of contaminated soil is limited to that shown in Figure 3-1.
- Excavation will comply with the unpaved based SSL (i.e., unrestricted land use).

6.2.1 Protection of Human Health and the Environment

Alternative S2 is effective at protecting human health and the environment because it removes soil with COC concentrations greater than SSLs from the site. The replacement soil will have concentrations of soil COCs below their respective MCSs.

6.2.2 Attain MCS

Alternative S2 will permanently remove soil with COC concentrations greater than SSLs from the site. The MCS will be achieved at the completion of soil removal actions.

6.2.3 Control the Source of Releases

There are no ongoing sources of releases at SWMU 25; therefore, this issue is not applicable to Alternative S2.

6.2.4 Compliance with Applicable Standards for the Management of Generated Wastes

Excavated soil will be sampled and analyzed for waste characterization prior to disposal. Soil, decontamination waste, and personal protective equipment (PPE) will be disposed of in accordance with applicable regulations and permits. Offsite transportation and disposal will be performed by properly permitted and licensed subcontractors.

6.2.5 Other Factors (a) Long-term Reliability and Effectiveness

Alternative S2 would have long-term reliability and be effective for the site as long as all MCS exceedances are removed. The removal of contamination from the site would be permanent. Confirmation sampling would verify that the excavations have removed soil exceedances. It is much less likely any significant amount of soil with concentrations above the MCS will be left in place; sitewide average concentrations will be below the unrestricted MCS.

6.2.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative S2 reduces the mobility of the contaminated soil by transporting it to a regulated containment facility (landfill). Treatment will not be required unless the soil exhibits toxicity characteristics per Title 40 Code of Federal Regulations Part 261.24. If required, soil will be treated (stabilized/fixated) at the disposal facility to further reduce mobility of the arsenic and BEQs.

6.2.7 Other Factors (c) Short-term Effectiveness

The excavation and hauling of contaminated soil in Alternative S2 has the potential to create dust containing contaminated soil particles. However, standard engineering controls such as dust suppression during excavation, tarp covers on trucks, and worker PPE to prevent dust inhalation will be implemented. Thus, with controls, the alternative provides short-term effectiveness in preventing ingestion of, or contact with, the contaminated soil, and minimizes the potential for migration of soil particles. The technologies for dust control and worker protection are well-established and robust. No unmanageable hazards would be created during implementation.

6.2.8 Other Factors (d) Implementability

Alternative S2 is relatively easy to implement. Most of the required activities have been routinely implemented at other nearby sites using standard equipment and procedures. Utility clearance, subcontracting, waste characterization, and base approval are customary activities. The field implementation of this remedy is estimated to require 1 to 2 weeks, and the benefits will be immediate. There is ample offsite capacity for disposal (and treatment, if required) of the contaminated soil.

6.2.9 Other Factors (e) Cost

Appendix A presents the overall cost estimate for implementing this remedy. These costs reflect soil removal based on available sample results, plus removal and replacement of pavement. In summary, the costs include the following:

- Remove soil in areas at each occurrence of MCS exceedance.
- Perform confirmation tests in each area to confirm compliance with MCS.

Using the assumptions listed above, the total present value of Alternative S2 is $109,000.

6.3 Alternative GW1 – In situ Chemical Reduction with ZVI

Alternative GW1 involves the emplacement of ZVI to function as an electron donor in the oxidation-reduction reaction that results in hexavalent chromium being reduced to trivalent chromium.

The assumptions for Alternative GW1 include the following:

- With this alternative, it has been assumed that a base-wide LUC Management Plan (LUCMP) will be developed for the CNC. The plan will allow for restrictions on the use of groundwater at Combined SWMU 70 and other areas, and it will be developed outside the scope of this CMS.

- Periodic groundwater monitoring will be performed until results indicate that the hexavalent chromium has been reduced to levels below MCLs. Periodic groundwater sampling will be performed (e.g., annually) to monitor the effectiveness of the emplaced iron, as well as to assess the concentrations of the other groundwater COCs outside the target treatment area (TTA). It may be necessary, at some time in the future, to add additional ZVI to the groundwater system in order to supplement the iron that was emplaced as part of the pilot study. For cost estimating purposes, monitoring will be planned for a 20-year period.

6.3.1 Protection of Human Health and the Environment

Alternative GW1 would be effective at protecting human health because it would incorporate LUCs to prevent the ingestion of, and direct contact with, groundwater.

6.3.2 Attain MCS

Alternative GW1 could potentially attain the MCSs. As described in Section 3.2, the iron that was emplaced in January 2002 as part of the pilot study continues to be effective in reducing concentrations of hexavalent chromium. This alternative only focuses on reducing chromium concentrations within the TTA.

Elevated concentrations of hexavalent chromium and other COCs outside the TTA would not be impacted by the ZVI. Rather, monitoring wells with historically elevated levels of COCs outside the TTA would be monitored. With the "hot-spot" addressed by this alternative, it is anticipated that concentrations in the peripheral of the plume will decrease over time.

This is a valid assumption in light of the fact that the source of groundwater contamination has been removed, via several IMs, the residual contamination has been covered with an asphalt cap, and the most concentrated volume of contaminated groundwater appears to be effectively responding to treatment with ZVI.

For the purposes of this alternative, it has been assumed that 20 years would be required to achieve MCSs.

6.3.3 Control the Source of Releases

There are no ongoing sources of releases at Combined SWMU 70.

6.3.4 Compliance with Applicable Standards for the Management of Generated Wastes

Alternative GW1 would not generate any wastes that require special management. The primary generated waste would be purge water from monitoring wells, which could be easily managed to applicable standards.

6.3.5 Other Factors (a) Long-term Reliability and Effectiveness

Alternative GW1 would have adequate long-term reliability and effectiveness, provided that iron continues to act as an electron donor in the oxidation-reduction reaction involving hexavalent chromium. During the course of monitoring treatment efficiency, it may be determined that the iron in some areas is no longer able to sustain reducing conditions for hexavalent chromium. In this case, alternatives would be evaluated if further treatment is necessary. A presumptive remedy for Combined SWMU 70 would consist of further addition of ZVI. However, alternative treatment technologies may be more advantageous than ZVI in the future.

It is anticipated that COCs outside the TTA will reduce in concentration over time.

6.3.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative GW1 relies on the reduction of hexavalent chromium to reduce the toxicity, mobility, and volume of the contaminants via abiotic reduction. Additionally, the iron will also facilitate reductive dechlorination of chlorinated volatile organic compounds (CVOCs) in groundwater.

6.3.7 Other Factors (c) Short-term Effectiveness

Through the implementation of LUCs, Alternative GW1 would have short-term effectiveness in preventing ingestion of, or contact with, the contaminated groundwater. No significant short-term risks would be created using this alternative. Additionally, as the ZVI has already been emplaced, it is currently effective in reducing hexavalent chromium concentrations.

6.3.8 Other Factors (d) Implementability

The emplacement of the ZVI portion of Alternative GW1 has already been completed. Additional components of this alternative, yet to be implemented, is the monitoring program and LUCs.

6.3.9 Other Factors (e) Cost

The present value cost for Alternative GW1 is $476,000 over a 20-year period. Major components of this cost include annual groundwater monitoring of the site and reporting. Details of the cost estimate are presented in Appendix C. Additionally, a line item cost of $250,000 has been included to account for potentially necessary ZVI in the future. Available data at the site currently indicates that additional iron is not necessary. Additional iron may be necessary, in the future, if monitoring data indicate there is an inadequate source of iron in the groundwater to facilitate chemical reduction of hexavalent chromium. This additional iron (and cost), however, may not be necessary.

6.4 Alternative GW2 – Monitored Natural Attenuation with LUCs

6.4.1 Protection of Human Health and the Environment

Alternative GW2 would not be effective at protecting human health and the environment. Although the MNA may not be completely effective in reducing hexavalent chromium concentrations over time, the monitoring component of the alternative will allow the migration of the contaminant to be monitored. In the event that contaminants migrate in an unanticipated area, another alternative or additional LUC can be implemented to protect human health and the environment.

6.4.2 Attain MCS

Alternative GW2 could potentially attain the MCSs. However, the fact that hexavalent chromium concentrations at Combined SWMU 70 were so persistent prior to the implementation of the pilot study indicates the potential for success is not high.

6.4.3 Control the Source of Releases

There are no ongoing sources of releases at Combined SWMU 70.

6.4.4 Compliance with Applicable Standards for the Management of Generated Wastes

This alternative would not generate any wastes that require special management.

6.4.5 Other Factors (a) Long-term Reliability and Effectiveness

Alternative GW2 would have adequate long-term reliability and effectiveness, as LUCs would be required to prevent use of contaminated groundwater. Monitoring of the groundwater will identify potential exposure problems before they can happen. The potential effectiveness of the MNA alternative in reducing hexavalent chromium concentrations is not expected to be high in the hot-spot area. MNA is expected to be effective in the peripheral of the plume, where concentrations of COCs are significantly lower.

6.4.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative GW2 may reduce TMV in some areas. However, it is expected that reductions will not be significant.

6.4.7 Other Factors (c) Short-term Effectiveness

Alternative GW2 will be successful in preventing exposure to contaminated groundwater through LUCs and monitoring.

6.4.8 Other Factors (d) Implementability

Alternative GW2 would be easily implemented.

6.4.9 Other Factors (e) Cost

The present value cost for Alternative GW2 is $159,000 over a 20-year period. Major components of this cost include annual groundwater monitoring of the site and reporting. Details of the cost estimate are presented in Appendix C.

6.5 Comparative Ranking of Corrective Measure Alternatives

The overall ability of each corrective measure alternative to meet the evaluation criteria is described above. In Table 6-1, a comparative evaluation of the degree to which each alternative meets a particular criterion is presented. Alternative S1, Capping with LUCs, and Alternative GW1, In situ Chemical Reduction with ZVI and LUCs, are the preferred alternatives. These alternatives are described in greater detail in Sec. 6.0.

TABLE 6-1
Comparison Evaluation of the Alternatives
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Criterion	Alternative S1: Capping with LUCs	Alternative S2: Soil Excavation and Offsite Disposal
Overall Protection of Human Health and the Environment	Protects human health and the environment by minimizing infiltration and mobility of hexavalent chromium	Protects human health and the environment with removal of contaminant concentrations greater than MCSs.
Attainment of MCS	Will allow paved-based SSL of 56 mg/kg to be effective in protecting groundwater.	Is expected to achieve MCSs in a very short period of time and only requires removal of soil and replacement of removed asphalt.
Control of the source of releases	Source treatment completed as part of IM.	Source treatment completed as part of IM.
Compliance with applicable standards for the management of wastes	Complies with applicable standards.	Complies with applicable standards. Additional potential leaching sources removed.
Long-term Reliability and Effectiveness	Expected to be reliable and effective long-term. Regular cap inspections will ensure continued protection of groundwater.	Expected to be reliable and effective long-term, once soil is removed.
Reduction of Toxicity, Mobility, or Volume through Treatment	Reduces mobility via minimizing infiltration.	Reduces toxicity, mobility, and volume via removing contaminants above MCSs from the site.
Short-term Effectiveness	Effective in short-term due to use of LUC.	Effective in short-term due to removal of soil.
Implementability	Easily implemented	Easily implemented
Cost Ranking	Inexpensive	Inexpensive
Estimated Cost	$31,000	$109,000

TABLE 6-1
Comparison Evaluation of the Alternatives
CMS Report, Combined SWMU 70, Zone E, Charleston Naval Complex

Criterion	Alternative GW1: In Situ Chemical Reduction with ZVI and LUCs	Alternative GW2: MNA with LUCs
Overall Protection of Human Health and the Environment	Protects human health and the environment with LUCs until MCSs can be achieved.	Protects human health via LUCs.
Attainment of MCS	Is expected to achieve MCSs in 20 years with combination of emplaced iron and natural attenuation of other COCs.	Potential for MCSs to be achieved, but the likelihood for achieving this is unknown.
Control of the source of releases	Source treatment completed as part of IM. Additional treatment would occur under this alternative.	Source treatment completed as part of IM.
Compliance with applicable standards for the management of wastes	Complies with applicable standards.	Complies with applicable standards regarding waste generation (no wastes produced)
Long-term Reliability and Effectiveness	Expected to be reliable and effective long-term, once MCSs are achieved.	Level of reliability to provide significant reduction unknown. Peripheral of plume may be more amendable to MNA.
Reduction of Toxicity, Mobility, or Volume through Treatment	Reduces toxicity, mobility, and volume via chemical reduction of hexavalent chromium and reductive dechlorination of CVOCs.	Reduces TMV via MNA, where MNA can be successful. May not be significant in the hot spot area.
Short-term Effectiveness	Effective in short-term due to use of LUC.	Effective in short-term due to use of LUCs.
Implementability	Easily implemented	Easily implemented
Cost Ranking	Inexpensive	Inexpensive
Estimated Cost	$476,000	$159,000

7.0 Recommended Corrective Measure Alternative

Two corrective measure alternatives were evaluated for soil and two corrective measure alternatives were evaluated for groundwater, using the criteria described in Section 4.0 of this CMS report. These alternatives were:

- Alternative S1 – Capping with LUCs
- Alternative S2 – Soil Excavation and Offsite Disposal
- Alternative GW1 – In Situ Chemical Reduction with ZVI and LUCs
- Alternative GW2 – MNA with LUCs

The RAOs identified for soil at Combined SWMU 70 are:

1) Protect industrial receptors from contact with contaminated soils with COC concentrations that could cause unacceptable systemic or carcinogenic effects; and

2) Protect groundwater from leachability of contaminated soils with COC concentrations that potentially threaten groundwater quality.

The RAOs identified for the groundwater at Combined SWMU 70 are:

1) Prevent ingestion and direct/dermal contact with groundwater having unacceptable carcinogenic or non-carcinogenic risk, and

2) To restore the aquifer to beneficial use.

Both soil and groundwater alternatives protect human health and the environment by maintaining the current and planned future use of the site as industrial/commercial. For soil, both Alternatives S1 and S2 are effective in all criteria of the screening process. Alternative S2 allows for removal of contaminants so that LUCs will not be necessary for the soil. However, Alternative S2 costs 3 times more than Alternative S1 and does not provide for increased protection. For this reason the selected soil corrective measure is Alternative S1 - Capping with LUCs.

For groundwater, Alternative GW1 is superior to Alternative GW2. Although both alternatives protect human health and provide some level of treatment, the fact that the hot-spot in Combined SWMU 70 is not addressed with Alternative GW2 would mean the peripheral plume around the hot-spot would remain contaminated for a much longer period of time than if it were to be treated, as provided for in Alternative GW1. LUCs would prevent residential and other unrestricted land use, including installation of water supply wells, that could expose sensitive populations. For this reason, the selected groundwater corrective measure is Alternative GW1 - In situ Reduction via ZVI.

A LUCMP is being developed for the industrial areas of the CNC, and Combined SWMU 70 will be added to the plan. The LUCMP will limit future site activities to those that would limit exposure to groundwater. The groundwater appears to be moving at very slow velocity, due to the flat gradients at the site. This fact, in conjunction with the knowledge that deeper groundwater movement is impeded by the rising Ashley Formation, indicates the Combined SWMU 70 site does not pose a significant groundwater contamination migration risk in the future. Alternative GW1 includes monitoring of COCs in groundwater.

Should monitoring data indicate that Alternative GW1 is not as effective as expected, additional measures could be safely implemented.

8.0 References

CH2M-Jones. *Zone E RFI Report Addendum and CMS Work Plan, Combined SWMU 70, Revision 0*. 2002a.

CH2M-Jones. *Phase II CMS Work Plan, In Situ Reduction of Hexavalent Chromium Using ZVI, Revision 1*. 2002b.

EnSafe Inc. *Zone E RCRA Facility Investigation (RFI) Report, NAVBASE Charleston, Revision 0.* November 1997.

NOTE: Original figure created in color

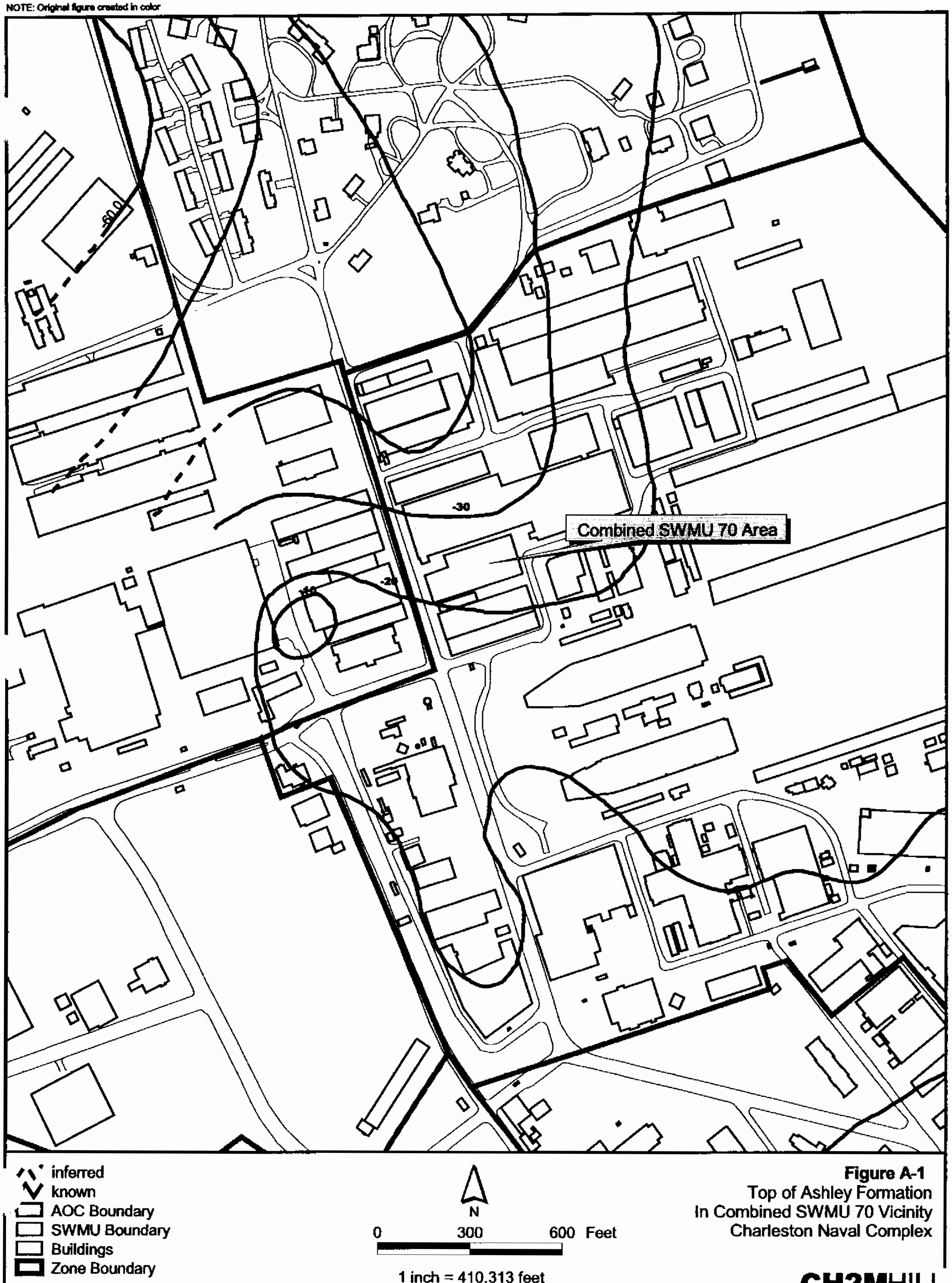
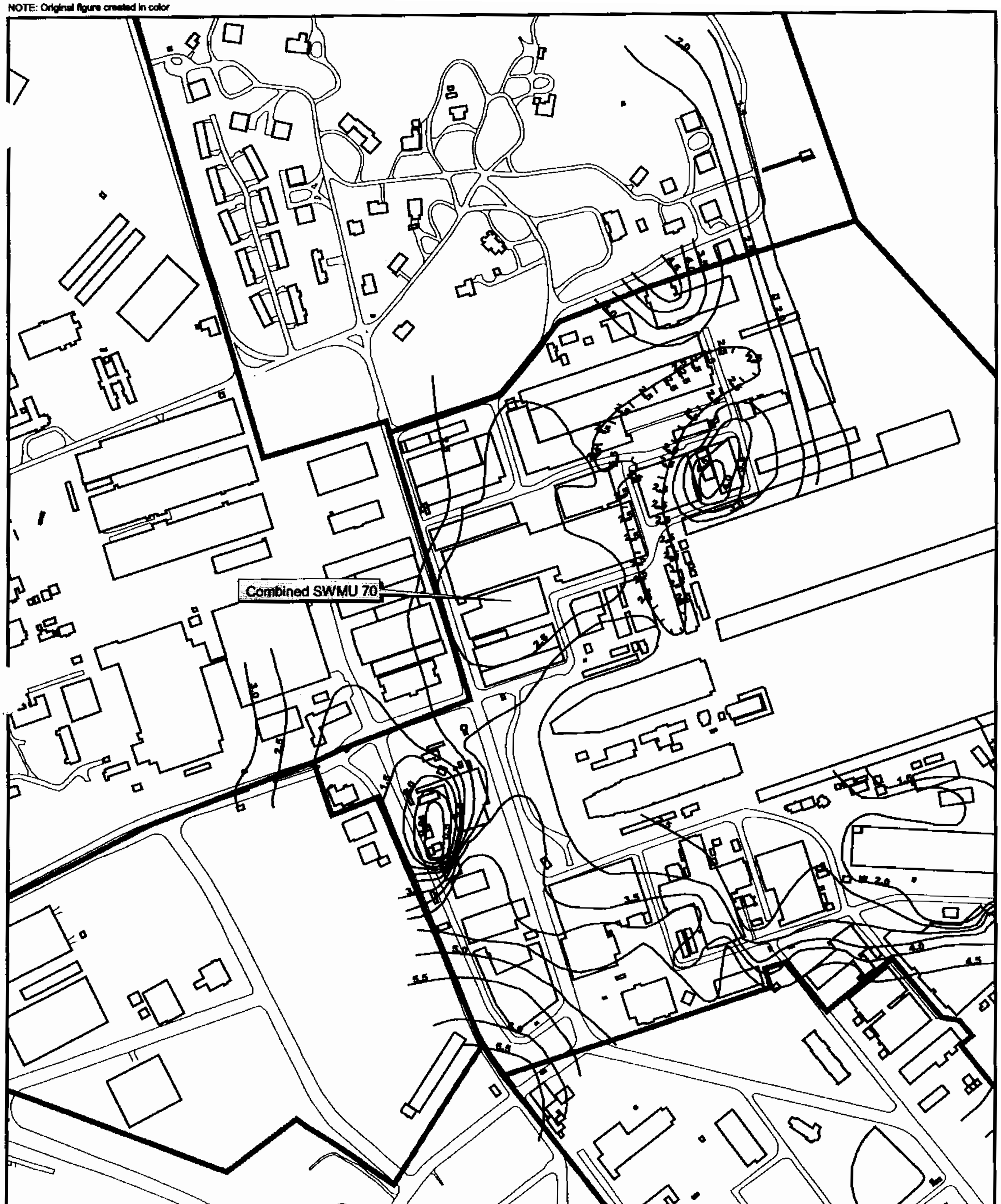


Figure A-1
Top of Ashley Formation
In Combined SWMU 70 Vicinity
Charleston Naval Complex

CH2MHILL

File Path: c:\118gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 24 Jul 2002 11:56, User: PFAVARA, RFIRA_CMSWP: Figure 7-10 Top of Ashley Formation

NOTE: Original figure created in color



Shallow Zone Groundwater Elevations (May 2002)
Roads - Lines
AOC Boundary
SWMU Boundary
Buildings
Zone Boundary

N

0 400 800 Feet

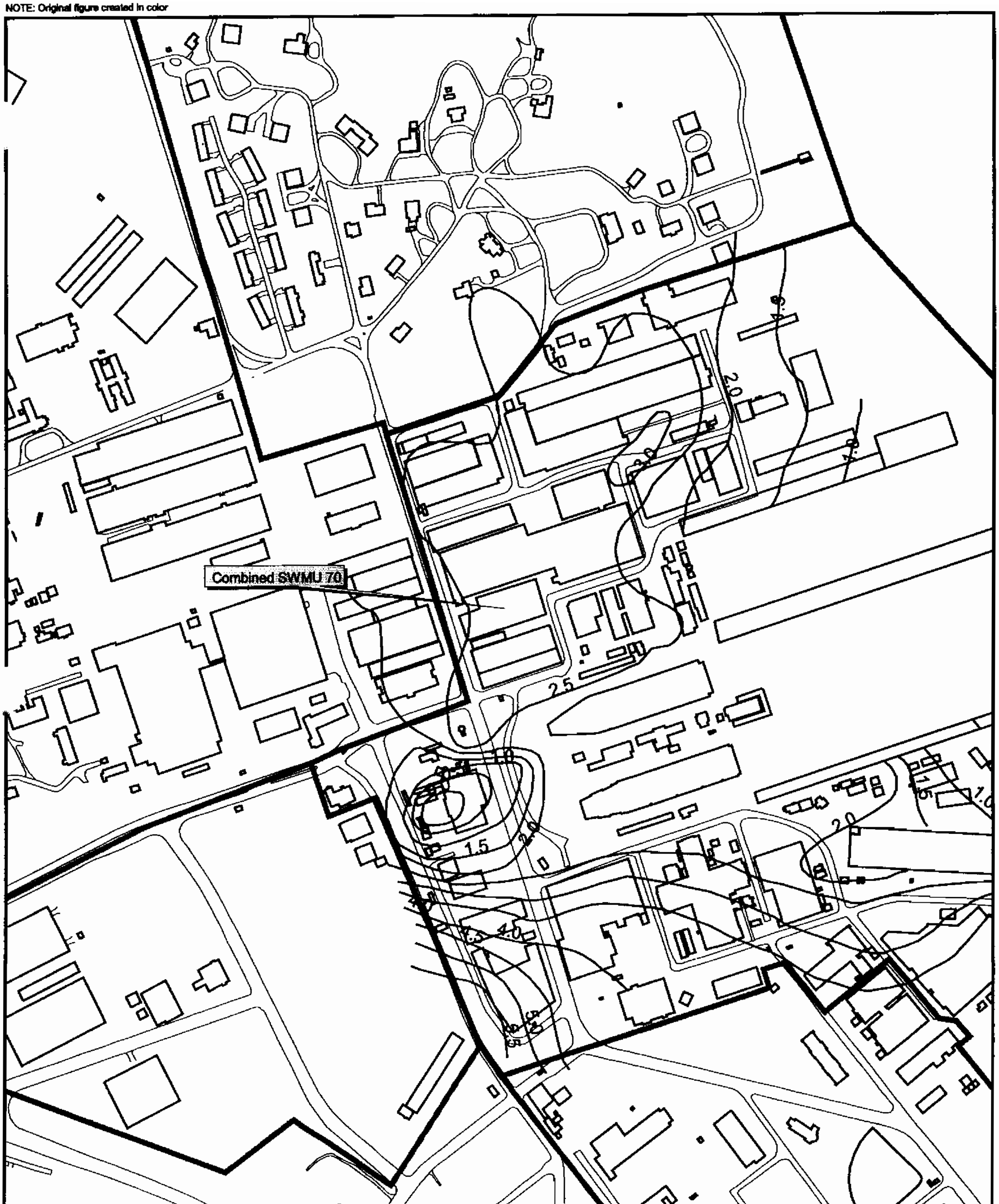
1 inch = 478.698 feet

Figure A-2
Shallow Groundwater Elevations
Combined SWMU 70 Vicinity
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_e\combined swmu 70\apra\rfira_cmswp.apr, Date: 16 Sep 2002 17:23, User: PFAVARA, RFIRA_CMSWP: Figure 7-12 Shallow Groundwater Elevation

NOTE: Original figure created in color



Deep Zone Groundwater Elevations (May 2002)
Roads - Lines
AOC Boundary
SWMU Boundary
Buildings
Zone Boundary

N

0 400 800 Feet

1 inch = 478.698 feet

Figure A-3
Deep Groundwater Elevations
Combined SWMU 70
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_e\combined swmu 70\aprs\rfira_cmswp.apr, Date: 16 Sep 2002 17:25, User: PFAVARA, RFIRA_CMSWP: Figure 7-13 Deep Groundwater Elevations

Appendix B-1

		E025SB028		E025SB029		E025SB030		E025SB031	
	SampleID	025SB02803 (3-5ft)		025SB02903 (3-5ft)		025SB03003 (3-5ft)		025SB03103 (3-5ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/30/2002		12/30/2002		12/30/2002		12/30/2002	
	DateAnalyzed	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	SDGNumber	72656		72656		72656		72656	
Parameter	**Units**								
Antimony	mg/kg	0.814	UJ	0.783	UJ	0.722	UJ	0.831	UJ
Cadmium	mg/kg	24.4	J	11.3	J	4.37	J	3.67	J
Chromium, Total	mg/kg	49.3	J	25.3	J	87.7	J	838	J

	StationID	E025SB032		E025SB033		E025SB034		E025SB035	
	SampleID	025SB03203 (3-5ft)		025SB03303 (3-5ft)		025SB03403 (3-5ft)		025SB03503 (3-5ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/30/2002		12/30/2002		12/30/2002		12/30/2002	
	DateAnalyzed	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	SDGNumber	72656		72656		72656		72656	
Parameter	**Units**								
Antimony	mg/kg	0.724	UJ	1.22	J	0.798	UJ	0.718	UJ
Cadmium	mg/kg	6.22	J	4.76	J	4.27	J	0.191	J
Chromium, Total	mg/kg	349	J	1300	J	628	J	391	J

	StationID	E025SB036		E025SB036		E025SB037		E025SB038	
	SampleID	025CB03603 (3-5ft)		025SB03603 (3-5ft)		025SB03703 (3-5ft)		025SB03803 (3-5ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/30/2002		12/30/2002		12/30/2002		12/30/2002	
	DateAnalyzed	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	SDGNumber	72656		72656		72654		72654	
Parameter	**Units**								
Antimony	mg/kg	0.756	UJ	0.707	UJ	3.91	J	6.25	J
Cadmium	mg/kg	0.046	UJ	0.055	UJ	2.66	=	0.589	J
Chromium, Total	mg/kg	222	J	232	J	5870	=	10000	=

Parameter	Units	E025SB028		E025SB029		E025SB031		E025SB033	
SampleID		025SB02803 (3-5ft)		025SB02903 (3-5ft)		025SB03103 (3-5ft)		025SB03303 (3-5ft)	
DateCollected		12/23/2002		12/23/2002		12/23/2002		12/23/2002	
DateExtracted		03/03/2003		03/03/2003		03/03/2003		03/03/2003	
DateAnalyzed		03/04/2003		03/04/2003		03/04/2003		03/04/2003	
SDGNumber		75465		75465		75465		75465	
Cadmium, SPLP	mg/L	0.011	J	0.005	J	0.002	U	0.002	U
Chromium, SPLP	mg/L	0.028	J	0.02	J	0.262	J	0.725	=

	StationID	E025SB038	
	SampleID	025SB03803 (3-5ft)	
	DateCollected	12/23/2002	
	DateExtracted	03/03/2003	
	DateAnalyzed	03/04/2003	
	SDGNumber	75465	
Parameter	**Units**		
Cadmium, SPLP	mg/L	0.002	U
Chromium, SPLP	mg/L	2.58	=

Analytical Data Summary

	StationID	E025SB028		E025SB029		E025SB030		E025SB031	
	SampleID	025SB02803 (3-5ft)		025SB02903 (3-5ft)		025SB03003 (3-5ft)		025SB03103 (3-5ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/31/2002		12/31/2002		01/02/2003		01/02/2003	
	DateAnalyzed	01/02/2003		01/02/2003		01/03/2003		01/03/2003	
	SDGNumber	72656		72656		72656		72656	
Parameter	**Units**								
Chromium (Hexavalent)	mg/kg	0.741	=	0.54	=	0.489	=	4.89	=

	StationID	E025SB032		E025SB033		E025SB034		E025SB035	
	SampleID	025SB03203 (3-5ft)		025SB03303 (3-5ft)		025SB03403 (3-5ft)		025SB03503 (3-5ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	01/02/2003		01/02/2003		01/02/2003		01/02/2003	
	DateAnalyzed	01/03/2003		01/03/2003		01/03/2003		01/03/2003	
	SDGNumber	72656		72656		72656		72656	
Parameter	**Units**								
Chromium (Hexavalent)	mg/kg	20.2	=	0.737	=	11.9	=	2.59	=

	StationID	E025SB036		E025SB036		E025SB037		E025SB038	
	SampleID	025CB03603 (3-5ft)		025SB03603 (3-5ft)		025SB03703 (3-5ft)		025SB03803 (3-5ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	01/02/2003		01/02/2003		12/31/2002		12/31/2002	
	DateAnalyzed	01/03/2003		01/03/2003		01/02/2003		01/02/2003	
	SDGNumber	72656		72656		72654		72654	
Parameter	**Units**								
Chromium (Hexavalent)	mg/kg	1.49	J	1.98	=	65.8	=	81	=

Parameter	Units						
StationID		E025SB028		E025SB029		E025SB030		E025S
SampleID		025SB02803 (3-5ft)		025SB02903 (3-5ft)		025SB03003 (3-5ft)		025SB031
DateCollected		12/23/2002		12/23/2002		12/23/2002		12/23
DateExtracted								
DateAnalyzed		12/27/2002		12/27/2002		12/27/2002		12/27
SDGNumber		72661		72658		72658		726
Parameter	**Units**							
Chromium (Hexavalent), SPLP	mg/L	0.01	UJ	0.008	J	0.049	J	0.119

	StationID	B031		E025SB032		E025SB033		E025SB034	
	SampleID	03 (3-5ft)		025SB03203 (3-5ft)		025SB03303 (3-5ft)		025SB03403 (3-5ft)	
	DateCollected	/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted								
	DateAnalyzed	/2002		12/27/2002		12/27/2002		12/27/2002	
	SDGNumber	58		72658		72658		72658	
Parameter	**Units**								
Chromium (Hexavalent), SPLP	mg/L	J		0.047	J	0.555	J	0.302	J

Analytical Data Summary

	StationID	E025SB035		E025SB036		E025SB036		E025S
	SampleID	025SB03503 (3-5ft)		025CB03603 (3-5ft)		025SB03603 (3-5ft)		025SB03
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23
	DateExtracted							
	DateAnalyzed	12/27/2002		12/27/2002		12/27/2002		12/27
	SDGNumber	72658		72658		72658		72
Parameter	**Units**							
Chromium (Hexavalent), SPLP	mg/L	0.108	J	0.292	J	0.282	J	2.24

	StationID	B037	E025SB038	
	SampleID	03 (3-5ft)	025SB03803 (3-5ft)	
	DateCollected	/2002	12/23/2002	
	DateExtracted			
	DateAnalyzed	/2002	01/03/2003	
	SDGNumber	58	72700	
Parameter	**Units**			
Chromium (Hexavalent), SPLP	mg/L	J	3.16	J

Parameter	Units	E025SB028		E025SB029		E025SB029		E025SB030	
	SampleID	025SB02801 (0-1ft)		025CB02901 (0-1ft)		025SB02901 (0-1ft)		025SB03001 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/27/2002		12/27/2002		12/27/2002		12/27/2002	
	DateAnalyzed	12/28/2002		12/28/2002		12/28/2002		12/28/2002	
	SDGNumber	72654		72654		72654		72654	
Benzo(g,h,i)Perylene	ug/kg	192	J	36.2	UJ	36.6	UJ	155	J
Naphthalene	ug/kg	35.7	U	36.2	U	36.6	U	36.3	U
Acenaphthylene	ug/kg	35.7	U	36.2	U	36.6	U	36.3	U
Acenaphthene	ug/kg	9.2	J	36.2	U	36.6	U	36.3	U
Fluorene	ug/kg	6.1	J	36.2	U	36.6	U	36.3	U
Phenanthrene	ug/kg	84.6	=	36.2	U	36.6	U	24.2	J
Anthracene	ug/kg	20.8	J	36.2	U	36.6	U	36.3	U
Fluoranthene	ug/kg	170	=	36.2	U	36.6	U	66.2	=
Pyrene	ug/kg	159	J	36.2	U	36.6	U	64.9	J
Benzo(a)Anthracene	ug/kg	35.7	U	36.2	U	36.6	U	36.5	=
Chrysene	ug/kg	129	=	36.2	U	36.6	U	48.5	=
Benzo(b)Fluoranthene	ug/kg	35.7	U	36.2	U	36.6	U	71.1	=
Benzo(k)Fluoranthene	ug/kg	186	=	36.2	U	36.6	U	36.3	U
Benzo(a)Pyrene	ug/kg	112	=	36.2	U	36.6	U	39.8	=
Indeno(1,2,3-c,d)pyrene	ug/kg	203	J	36.2	UJ	36.6	UJ	169	J
Dibenz(a,h)anthracene	ug/kg	35.7	UJ	36.2	UJ	36.6	UJ	175	J

	StationID	E025SB031		E025SB032		E025SB033		E025SB034	
	SampleID	025SB03101 (0-1ft)		025SB03201 (0-1ft)		025SB03301 (0-1ft)		025SB03401 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/27/2002		12/27/2002		12/27/2002		12/27/2002	
	DateAnalyzed	12/28/2002		12/28/2002		12/28/2002		12/28/2002	
	SDGNumber	72654		72654		72654		72654	
Parameter	**Units**								
Benzo(g,h,i)Perylene	ug/kg	37.1	UJ	36.7	UJ	217	J	156	J
Naphthalene	ug/kg	37.1	U	36.7	U	37	U	36.8	U
Acenaphthylene	ug/kg	37.1	U	36.7	U	37	U	36.8	U
Acenaphthene	ug/kg	37.1	U	36.7	U	37	U	36.8	U
Fluorene	ug/kg	37.1	U	36.7	U	37	U	36.8	U
Phenanthrene	ug/kg	37.1	U	36.7	U	27.7	J	22.2	J
Anthracene	ug/kg	37.1	U	36.7	U	37	U	36.8	U
Fluoranthene	ug/kg	37.1	U	32.7	J	99.4	=	65.2	=
Pyrene	ug/kg	37.1	U	38.8	J	132	J	84.1	J
Benzo(a)Anthracene	ug/kg	37.1	U	36.7	U	37	U	36.8	U
Chrysene	ug/kg	37.1	U	22.2	J	119	=	53.8	=
Benzo(b)Fluoranthene	ug/kg	37.1	U	36.7	U	37	U	36.8	U
Benzo(k)Fluoranthene	ug/kg	37.1	U	38.8	=	344	=	85.4	=
Benzo(a)Pyrene	ug/kg	37.1	U	36.7	U	162	=	49.8	=
Indeno(1,2,3-c,d)pyrene	ug/kg	37.1	UJ	36.7	UJ	227	J	36.8	UJ
Dibenz(a,h)anthracene	ug/kg	37.1	UJ	36.7	UJ	37	UJ	36.8	UJ

StationID		E025SB035		E025SB036		E025SB037		E025SB038	
SampleID		025SB03501 (0-1ft)		025SB03601 (0-1ft)		025SB03701 (0-1ft)		025SB03801 (0-1ft)	
DateCollected		12/23/2002		12/23/2002		12/23/2002		12/23/2002	
DateExtracted		12/27/2002		12/27/2002		12/27/2002		12/27/2002	
DateAnalyzed		12/28/2002		12/28/2002		12/28/2002		12/28/2002	
SDGNumber		72654		72654		72654		72654	
Parameter	**Units**								
Benzo(g,h,i)Perylene	ug/kg	247	J	2170	J	291	J	273	J
Naphthalene	ug/kg	36.7	U	146	U	37.6	U	37.4	U
Acenaphthylene	ug/kg	36.7	U	244	=	24.2	J	37.4	U
Acenaphthene	ug/kg	36.7	U	146	U	37.6	U	37.4	U
Fluorene	ug/kg	36.7	U	37.2	J	11.3	J	37.4	U
Phenanthrene	ug/kg	92	=	1520	=	259	=	118	=
Anthracene	ug/kg	36.7	U	308	=	43.3	=	19.2	J
Fluoranthene	ug/kg	339	=	7400	=	507	=	385	=
Pyrene	ug/kg	395	J	7550	J	524	J	384	J
Benzo(a)Anthracene	ug/kg	36.7	U	3930	=	276	=	37.4	U
Chrysene	ug/kg	224	=	3940	=	296	=	216	=
Benzo(b)Fluoranthene	ug/kg	36.7	U	146	U	37.6	U	37.4	U
Benzo(k)Fluoranthene	ug/kg	388	=	6180	=	437	=	367	=
Benzo(a)Pyrene	ug/kg	232	=	4100	=	277	=	224	=
Indeno(1,2,3-c,d)pyrene	ug/kg	256	J	2140	J	283	J	263	J
Dibenz(a,h)anthracene	ug/kg	36.7	UJ	146	UJ	37.6	UJ	37.4	UJ

	StationID	E025SB028		E025SB029		E025SB029		E025SB030	
	SampleID	025SB02801 (0-1ft)		025CB02901 (0-1ft)		025SB02901 (0-1ft)		025SB03001 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/30/2002		12/30/2002		12/30/2002		12/30/2002	
	DateAnalyzed	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	SDGNumber	72654		72654		72654		72654	
Parameter	**Units**								
Antimony	mg/kg	0.688	UJ	0.718	UJ	0.692	UJ	0.686	UJ
Cadmium	mg/kg	43.4	=	8.51	=	20.9	=	5.74	=
Chromium, Total	mg/kg	122	=	39.5	=	40.5	=	171	=

	StationID	E025SB031		E025SB032		E025SB033		E025SB034	
	SampleID	025SB03101 (0-1ft)		025SB03201 (0-1ft)		025SB03301 (0-1ft)		025SB03401 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/30/2002		12/30/2002		12/30/2002		12/30/2002	
	DateAnalyzed	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	SDGNumber	72654		72654		72654		72654	
Parameter	**Units**								
Antimony	mg/kg	0.676	UJ	0.734	UJ	1.26	J	0.729	UJ
Cadmium	mg/kg	4.39	=	2.2	=	3.45	=	10.3	=
Chromium, Total	mg/kg	1140	=	411	=	1710	=	541	=

	StationID	E025SB035		E025SB036		E025SB037		E025SB038	
	SampleID	025SB03501 (0-1ft)		025SB03601 (0-1ft)		025SB03701 (0-1ft)		025SB03801 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/30/2002		12/30/2002		12/30/2002		12/30/2002	
	DateAnalyzed	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	SDGNumber	72654		72654		72654		72654	
Parameter	**Units**								
Antimony	mg/kg	0.727	UJ	0.71	UJ	2.63	J	3.16	J
Cadmium	mg/kg	2.4	=	0.21	J	2.57	=	0.424	J
Chromium, Total	mg/kg	634	=	126	=	3390	=	7790	=

Parameter	Units	E025SB028		E025SB029		E025SB031		E025SB033	
	SampleID	025SB02801 (0-1ft)		025SB02901 (0-1ft)		025SB03101 (0-1ft)		025SB03301 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	03/03/2003		03/03/2003		03/03/2003		03/03/2003	
	DateAnalyzed	03/04/2003		03/04/2003		03/04/2003		03/04/2003	
	SDGNumber	75465		75465		75465		75465	
Cadmium, SPLP	mg/L	0.009	J	0.01	J	0.002	U	0.002	U
Chromium, SPLP	mg/L	0.054	J	0.055	J	0.572	=	1.44	=

Analytical Data Summary

	StationID	E025SB035		E025SB037	
	SampleID	025SB03501 (0-1ft)		025SB03701 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002	
	DateExtracted	03/03/2003		03/03/2003	
	DateAnalyzed	03/04/2003		03/04/2003	
	SDGNumber	75465		75465	
Parameter	**Units**				
Cadmium, SPLP	mg/L	0.002	U	0.002	U
Chromium, SPLP	mg/L	0.267	J	2.11	=

	StationID	E025SB028		E025SB029		E025SB029		E025SB030	
	SampleID	025SB02801 (0-1ft)		025CB02901 (0-1ft)		025SB02901 (0-1ft)		025SB03001 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	DateAnalyzed	01/02/2003		01/02/2003		01/02/2003		01/02/2003	
	SDGNumber	72654		72654		72654		72654	
Parameter	**Units**								
Chromium (Hexavalent)	mg/kg	0.551	=	0.928	=	2.06	=	2.78	=

	StationID	E025SB031		E025SB032		E025SB033		E025SB034	
	SampleID	025SB03101 (0-1ft)		025SB03201 (0-1ft)		025SB03301 (0-1ft)		025SB03401 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	DateAnalyzed	01/02/2003		01/02/2003		01/02/2003		01/02/2003	
	SDGNumber	72654		72654		72654		72654	
Parameter	**Units**								
Chromium (Hexavalent)	mg/kg	2.11	=	12.9	=	9.33	=	37.2	=

		E025SB035		E025SB036		E025SB037		E025SB038	
	StationID	E025SB035		E025SB036		E025SB037		E025SB038	
	SampleID	025SB03501 (0-1ft)		025SB03601 (0-1ft)		025SB03701 (0-1ft)		025SB03801 (0-1ft)	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted	12/31/2002		12/31/2002		12/31/2002		12/31/2002	
	DateAnalyzed	01/02/2003		01/02/2003		01/02/2003		01/02/2003	
	SDGNumber	72654		72654		72654		72654	
Parameter	**Units**								
Chromium (Hexavalent)	mg/kg	3.88	=	1.75	=	1.72	=	66.7	=

Analytical Data Summary

	StationID	E025SB028		E025SB029		E025SB029		E025S	
	SampleID	025SB02801 (0-1ft)		025CB02901 (0-1ft)		025SB02901 (0-1ft)		025SB03(	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23	
	DateExtracted								
	DateAnalyzed	12/27/2002		12/27/2002		12/27/2002		12/27	
	SDGNumber	72661		72658		72661		726	
Parameter	**Units**								
Chromium (Hexavalent), SPLP	mg/L	0.04	J	0.029	J	0.01	UJ	0.01	

	StationID	B030		E025SB031		E025SB032		E025SB033	
	SampleID	01 (0-1ft)		025SB03101 (0-1ft)		025SB03201 (0-1ft)		025SB03301 (0-1ft)	
	DateCollected	/2002		12/23/2002		12/23/2002		12/23/2002	
	DateExtracted								
	DateAnalyzed	/2002		12/27/2002		12/27/2002		12/27/2002	
	SDGNumber	58		72658		72658		72658	
Parameter	**Units**								
Chromium (Hexavalent), SPLP	mg/L		J	0.47	J	0.278	J	1.07	J

Parameter	Units								
	StationID	E025SB034		E025SB035		E025SB036		E025S	
	SampleID	025SB03401 (0-1ft)		025SB03501 (0-1ft)		025SB03601 (0-1ft)		025SB03	
	DateCollected	12/23/2002		12/23/2002		12/23/2002		12/23	
	DateExtracted								
	DateAnalyzed	12/27/2002		12/27/2002		12/27/2002		12/27	
	SDGNumber	72658		72658		72658		72	
Chromium (Hexavalent), SPLP	mg/L	0.212	J	0.192	J	0.02	J	1.61	

	StationID	B037		E025SB038	
	SampleID	01 (0-1ft)		025SB03801 (0-1ft)	
	DateCollected	/2002		12/23/2002	
	DateExtracted				
	DateAnalyzed	/2002		12/27/2002	
	SDGNumber	58		72658	
Parameter	**Units**				
Chromium (Hexavalent), SPLP	mg/L	J		0.92	J

Table B2-1 Dilution Attenuation Factor (DAF) Calculation
SWMUs 25 and 70, Zone E
Charleston Naval Complex, North Charleston, SC

Site(s) 25/70	Hydraulic Conductivity K (m/yr)	Hydraulic Gradient I (m/m)	Aquifer Thickness da (m)	Source Length Sw (m)	Infiltration Rate i (m/yr)	Mixing Zone d (m)	DAF
Unpaved	611.9	0.0021	8.19912	25.9	0.14	5.1	2.8
Paved	611.9	0.0021	8.19912	25.9	0.0086	2.9	17.8

K the value for the hydraulic conductivity is based on interpolation of CH2M Hill's map of hydraulic conductivities (k.apr, 5.5 ft/day ~ 611.9 m/yr).

I The hydraulic gradient is based on the distance (190 ft) between 3.8- and 3.4-foot shallow groundwater contours from Figure 2-6A (Zone E RFI, 1997).

da The aquifer thickness is based on Figure 2-5B from the Zone E RFI, 26.9 ft.

Sw The source length is the diagonally measured distance across SWMU 70 from eastern to western most corners (direction of groundwater flow) (85 ft ~ 25.9 m).

i Internal CH2MHILL Technical Memorandum, *Infiltration Variable Used in SSL Calculation*, 0.45 ft/yr for unpaved areas and 0.0283 ft/yr for paved areas, October 5, 20011.

d is the smaller of the aquifer thickness (da) or the result of the mixing zone equation:

$$d = (0.0112\ Sw^2)^{0.5} + da\{1 - \exp[(-Sw\ I')/(K\ I\ da)]\}$$

Cadmium		StationID	E025SB028	E025SB028	E025SB029
		SampleID	025SB02801 (0-1ft)	025SB02803 (3-5ft)	025SB02901 (0-1ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		43.4 =	24.4 J	20.9 =
SPLP Water Concentration	mg/L		0.009 J	0.011 J	0.01 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		4.34	2.44	2.09
Total contaminant mass in water	mg		0.018	0.022	0.02
Adjusted soil concentration	mg/kg		43.2	24.2	20.7
Kd	L/kg		4802	2198	2070
For DAF = 1, SSL = Kd x MCL					
DAF =	1		24.011	10.991	10.350
DAF =	2.8		68.266	31.248	29.426
DAF =	17.8		426.815	195.371	183.979
MCL, mg/L	0.005				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	1700				
SSL, DAF=1	8				
SSL, DAF=2.8	24				
SSL, DAF=17.8	151				
min/max soil concentration, mg/Kg	0.589 / 43.4				
min/max liquid concentration, mg/L	0.002 / 0.011				

Cadmium		StationID	E025SB029	E025SB031	E025SB031
		SampleID	025SB02903 (3-5ft)	025SB03101 (0-1ft)	025SB03103 (3-5ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		11.3 J	4.39 =	3.67 J
SPLP Water Concentration	mg/L		0.005 J	0.002 U	0.002 U
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		1.13	0.439	0.367
Total contaminant mass in water	mg		0.01	0.002	0.002
Adjusted soil concentration	mg/kg		11.2	4.4	3.7
Kd	L/kg		2240	2185	1825
For DAF = 1, SSL = Kd x MCL					
DAF =	1		11.200	10.925	9.125
DAF =	2.8		31.843	31.061	25.943
DAF =	17.8		199.088	194.200	162.203
MCL, mg/L	0.005				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	1700				
SSL, DAF=1	8				
SSL, DAF=2.8	24				
SSL, DAF=17.8	151				
min/max soil concentration, mg/Kg	0.589 / 43.4				
min/max liquid concentration, mg/L	0.002 / 0.011				

Cadmium

Parameter	Units		StationID / SampleID / DateCollected	E025SB033 / 025SB03301 (0-1ft) / 12/23/2002	E025SB033 / 025SB03303 (3-5ft) / 12/23/2002	E025SB035 / 025SB03501 (0-1ft) / 12/23/2002
Initial Soil Concentration	mg/kg			3.45 =	4.76 J	2.4 =
SPLP Water Concentration	mg/L			0.002 U	0.002 U	0.002 U
Soil mass	kg		0.1			
Water volume	L		2			
Total contaminant mass in soil	mg			0.345	0.476	0.24
Total contaminant mass in water	mg			0.002	0.002	0.002
Adjusted soil concentration	mg/kg			3.4	4.7	2.4
Kd	L/kg			1715	2370	1190
For DAF = 1, SSL = Kd x MCL						
	DAF =	1		8.575	11.850	5.950
	DAF =	2.8		24.380	33.691	16.916
	DAF =	17.8		152.427	210.642	105.765

MCL, mg/L	0.005
SSL = Kd x MCL x DAF	
geometric mean of Kd (excludes negitive values)	1700
SSL, DAF=1	8
SSL, DAF=2.8	24
SSL, DAF=17.8	151
min/max soil concentration, mg/Kg	0.589 / 43.4
min/max liquid concentration, mg/L	0.002 / 0.011

Cadmium		StationID	E025SB037	E025SB038
		SampleID	025SB03701 (0-1ft)	025SB03803 (3-5ft)
		DateCollected	12/23/2002	12/23/2002
Parameter	**Units**			
Initial Soil Concentration	mg/kg		2.57 =	0.589 J
SPLP Water Concentration	mg/L		0.002 U	0.002 U
Soil mass	kg	0.1		
Water volume	L	2		
Total contaminant mass in soil	mg		0.257	0.0589
Total contaminant mass in water	mg		0.002	0.002
Adjusted soil concentration	mg/kg		2.6	0.6
Kd	L/kg		1275	285
For DAF = 1, SSL = Kd x MCL				
DAF =	1		6.375	1.423
DAF =	2.8		18.125	4.044
DAF =	17.8		113.320	25.286
MCL, mg/L	0.005			
SSL = Kd x MCL x DAF				
geometric mean of Kd (excludes negitive values)	1700			
SSL, DAF=1	8			
SSL, DAF=2.8	24			
SSL, DAF=17.8	151			
min/max soil concentration, mg/Kg	0.589 / 43.4			
min/max liquid concentration, mg/L	0.002 / 0.011			

Trivalent Chromium (Cr^{+3})
(based on total chromium concentrations)

Parameter	Units		E025SB028	E025SB028	E025SB029
		StationID	E025SB028	E025SB028	E025SB029
		SampleID	025SB02801 (0-1ft)	025SB02803 (3-5ft)	025SB02901 (0-1ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Initial Soil Concentration	mg/kg		122 =	49.3 J	40.5 =
SPLP Water Concentration	mg/L		0.054 J	0.028 J	0.055 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		12.2	4.93	4.05
Total contaminant mass in water	mg		0.108	0.056	0.11
Adjusted soil concentration	mg/kg		120.9	48.7	39.4
Kd	L/kg		2239	1741	716
For DAF = 1, SSL = Kd x MCL					
DAF =	1		123,159	95,739	39,400
DAF =	2.8		350,153	272,196	112,018
DAF =	17.8		2,189,243	1,701,834	700,363
MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+3} used in place of MCL)	55				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	1,802				
SSL, DAF=1	99,103				
SSL, DAF=2.8	281,760				
SSL, DAF=17.8	1,761,635				
min/max soil concentration, mg/Kg	25.3 / 10000				
min/max liquid concentration, mg/L	0.02 / 2.58				

Trivalent Chromium (Cr^{+3})
(based on total chromium concentrations)

Parameter	Units		E025SB029	E025SB031	E025SB031
		StationID	E025SB029	E025SB031	E025SB031
		SampleID	025SB02903 (3-5ft)	025SB03101 (0-1ft)	025SB03103 (3-5ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Initial Soil Concentration	mg/kg		25.3 J	1140 =	838 J
SPLP Water Concentration	mg/L		0.02 J	0.572 =	0.262 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		2.53	114	83.8
Total contaminant mass in water	mg		0.04	1.144	0.524
Adjusted soil concentration	mg/kg		24.9	1128.6	832.8
Kd	L/kg		1245	1973	3178
For DAF = 1, SSL = Kd x MCL					
DAF =	1		68,475	108,515	174,816
DAF =	2.8		194,681	308,519	497,018
DAF =	17.8		1,217,192	1,928,938	3,107,479

MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+3} used in place of MCL)	55
SSL = Kd x MCL x DAF	
geometric mean of Kd (excludes negitive values)	1,802
SSL, DAF=1	99,103
SSL, DAF=2.8	281,760
SSL, DAF=17.8	1,761,635
min/max soil concentration, mg/Kg	25.3 / 10000
min/max liquid concentration, mg/L	0.02 / 2.58

Trivalent Chromium (Cr^{+3}) (based on total chromium concentrations)		**StationID**	E025SB033	E025SB033	E025SB035
		SampleID	025SB03301 (0-1ft)	025SB03303 (3-5ft)	025SB03501 (0-1ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		1710 =	1300 J	634 =
SPLP Water Concentration	mg/L		1.44 =	0.725 =	0.267 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		171	130	63.4
Total contaminant mass in water	mg		2.88	1.45	0.534
Adjusted soil concentration	mg/kg		1681.2	1285.5	628.7
Kd	L/kg		1168	1773	2355
For DAF = 1, SSL = Kd x MCL					
	DAF =	1	64,213	97,521	129,499
	DAF =	2.8	182,562	277,260	368,178
	DAF =	17.8	1,141,423	1,733,500	2,301,941
MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+3} used in place of MCL)		55			
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)		1,802			
SSL, DAF=1		99,103			
SSL, DAF=2.8		281,760			
SSL, DAF=17.8		1,761,635			
min/max soil concentration, mg/Kg		25.3 / 10000			
min/max liquid concentration, mg/L		0.02 / 2.58			

Trivalent Chromium (Cr^{+3})
(based on total chromium concentrations)

Parameter	Units		E025SB037	E025SB038
		StationID	E025SB037	E025SB038
		SampleID	025SB03701 (0-1ft)	025SB03803 (3-5ft)
		DateCollected	12/23/2002	12/23/2002
Initial Soil Concentration	mg/kg		3390 =	10000 =
SPLP Water Concentration	mg/L		2.11 =	2.58 =
Soil mass	kg	0.1		
Water volume	L	2		
Total contaminant mass in soil	mg		339	1000
Total contaminant mass in water	mg		4.22	5.16
Adjusted soil concentration	mg/kg		3347.8	9948.4
Kd	L/kg		1587	3856

For DAF = 1, SSL = Kd x MCL

		E025SB037	E025SB038
DAF =	1	87,265	212,078
DAF =	2.8	248,102	602,958
DAF =	17.8	1,551,196	3,769,843

MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+3} used in place of MCL) 55

SSL = Kd x MCL x DAF

geometric mean of Kd (excludes negitive values)	1,802
SSL, DAF=1	99,103
SSL, DAF=2.8	281,760
SSL, DAF=17.8	1,761,635
min/max soil concentration, mg/Kg	25.3 / 10000
min/max liquid concentration, mg/L	0.02 / 2.58

Hexavalent Chromium (Cr^{+6})		StationID	E025SB028	E025SB028	E025SB029
		SampleID	025SB02801 (0-1ft)	025SB02803 (3-5ft)	025CB02901 (0-1ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		0.551 =	0.741 =	0.928 =
SPLP Water Concentration	mg/L		0.04 J	0.01 UJ	0.029 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		0.0551	0.0741	0.0928
Total contaminant mass in water	mg		0.08	0.01	0.058
Adjusted soil concentration	mg/kg		-0.2	0.6	0.3
Kd	L/kg		-6.2	64	12
For DAF = 1, SSL = Kd x MCL					
DAF =	1		-0.685	7.051	1.320
DAF =	2.8		-1.947	20.047	3.753
DAF =	17.8		-12.172	125.337	23.464
MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL)	0.11				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	29				
SSL, DAF=1	3.14				
SSL, DAF=2.8	9				
SSL, DAF=17.8	56				
min/max soil concentration, mg/Kg	0.489 / 20.2				
min/max liquid concentration, mg/L	0.008 / 0.47				

Hexavalent Chromium (Cr^{+6})	StationID		E025SB029	E025SB029	E025SB030
	SampleID		025SB02901 (0-1ft)	025SB02903 (3-5ft)	025SB03001 (0-1ft)
	DateCollected		12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		2.06 =	0.54 =	2.78 =
SPLP Water Concentration	mg/L		0.01 UJ	0.008 J	0.01 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		0.206	0.054	0.278
Total contaminant mass in water	mg		0.01	0.016	0.02
Adjusted soil concentration	mg/kg		2.0	0.4	2.6
Kd	L/kg		196	48	258
For DAF = 1, SSL = Kd x MCL					
DAF =	1		21.560	5.225	28.380
DAF =	2.8		61.297	14.855	80.687
DAF =	17.8		383.244	92.878	504.475

MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL)	0.11
SSL = Kd x MCL x DAF	
geometric mean of Kd (excludes negitive values)	29
SSL, DAF=1	3.14
SSL, DAF=2.8	9
SSL, DAF=17.8	56
min/max soil concentration, mg/Kg	0.489 / 20.2
min/max liquid concentration, mg/L	0.008 / 0.47

Hexavalent Chromium (Cr^{+6})	StationID		E025SB030	E025SB031	E025SB031
	SampleID		025SB03003 (3-5ft)	025SB03101 (0-1ft)	025SB03103 (3-5ft)
	DateCollected		12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		0.489 =	2.11 =	4.89 =
SPLP Water Concentration	mg/L		0.049 J	0.47 J	0.119 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		0.0489	0.211	0.489
Total contaminant mass in water	mg		0.098	0.94	0.238
Adjusted soil concentration	mg/kg		-0.5	-7.3	2.5
Kd	L/kg		-10	-16	21
For DAF = 1, SSL = Kd x MCL					
DAF =	1		-1.102	-1.706	2.320
DAF =	2.8		-3.134	-4.851	6.596
DAF =	17.8		-19.593	-30.328	41.243
MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL)	0.11				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	29				
SSL, DAF=1	3.14				
SSL, DAF=2.8	9				
SSL, DAF=17.8	56				
min/max soil concentration, mg/Kg	0.489 / 20.2				
min/max liquid concentration, mg/L	0.008 / 0.47				

Hexavalent Chromium (Cr^{+6})		StationID	E025SB032	E025SB032	E025SB033
		SampleID	025SB03201 (0-1ft)	025SB03203 (3-5ft)	025SB03301 (0-1ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		12.9 =	20.2 =	9.33 =
SPLP Water Concentration	mg/L		0.278 J	0.047 J	1.07 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		1.29	2.02	0.933
Total contaminant mass in water	mg		0.556	0.094	2.14
Adjusted soil concentration	mg/kg		7.3	19.3	-12.1
Kd	L/kg		26	410	-11
For DAF = 1, SSL = Kd x MCL					
DAF =	1		2.904	45.077	-1.241
DAF =	2.8		8.257	128.157	-3.528
DAF =	17.8		51.626	801.269	-22.057

MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL)	0.11
SSL = Kd x MCL x DAF	
geometric mean of Kd (excludes negitive values)	29
SSL, DAF=1	3.14
SSL, DAF=2.8	9
SSL, DAF=17.8	56
min/max soil concentration, mg/Kg	0.489 / 20.2
min/max liquid concentration, mg/L	0.008 / 0.47

Hexavalent Chromium (Cr^{+6})	StationID		E025SB033	E025SB034	E025SB034
	SampleID		025SB03303 (3-5ft)	025SB03401 (0-1ft)	025SB03403 (3-5ft)
	DateCollected		12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		0.737 =	37.2 =	11.9 =
SPLP Water Concentration	mg/L		0.555 J	0.212 J	0.302 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		0.0737	3.72	1.19
Total contaminant mass in water	mg		1.11	0.424	0.604
Adjusted soil concentration	mg/kg		-10.4	33.0	5.9
Kd	L/kg		-19	155	19
For DAF = 1, SSL = Kd x MCL					
DAF =	1		-2.054	17.102	2.134
DAF =	2.8		-5.840	48.622	6.068
DAF =	17.8		-36.510	303.998	37.941
MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL)	0.11				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	29				
SSL, DAF=1	3.14				
SSL, DAF=2.8	9				
SSL, DAF=17.8	56				
min/max soil concentration, mg/Kg	0.489 / 20.2				
min/max liquid concentration, mg/L	0.008 / 0.47				

Hexavalent Chromium (Cr^{+6})		StationID	E025SB035	E025SB035	E025SB036
		SampleID	025SB03501 (0-1ft)	025SB03503 (3-5ft)	025CB03603 (3-5ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		3.88 =	2.59 =	1.49 J
SPLP Water Concentration	mg/L		0.192 J	0.108 J	0.292 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		0.388	0.259	0.149
Total contaminant mass in water	mg		0.384	0.216	0.584
Adjusted soil concentration	mg/kg		0.0	0.4	-4.4
Kd	L/kg		0.21	4.0	-15
For DAF = 1, SSL = Kd x MCL					
DAF =	1		0.023	0.438	-1.639
DAF =	2.8		0.065	1.245	-4.659
DAF =	17.8		0.407	7.785	-29.129
MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL)	0.11				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	29				
SSL, DAF=1	3.14				
SSL, DAF=2.8	9				
SSL, DAF=17.8	56				
min/max soil concentration, mg/Kg	0.489 / 20.2				
min/max liquid concentration, mg/L	0.008 / 0.47				

Hexavalent Chromium (Cr^{+6})

Parameter	Units		E025SB036	E025SB036	E025SB037
	StationID		E025SB036	E025SB036	E025SB037
	SampleID		025SB03601 (0-1ft)	025SB03603 (3-5ft)	025SB03701 (0-1ft)
	DateCollected		12/23/2002	12/23/2002	12/23/2002
Initial Soil Concentration	mg/kg		1.75 =	1.98 =	1.72 =
SPLP Water Concentration	mg/L		0.02 J	0.282 J	1.61 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		0.175	0.198	0.172
Total contaminant mass in water	mg		0.04	0.564	3.22
Adjusted soil concentration	mg/kg		1.4	-3.7	-30.5
Kd	L/kg		68	-13	-19

For DAF = 1, SSL = Kd x MCL

DAF =	1	7.425	-1.428	-2.082
DAF =	2.8	21.110	-4.059	-5.921
DAF =	17.8	131.985	-25.378	-37.018

MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL) 0.11

SSL = Kd x MCL x DAF

geometric mean of Kd (excludes negitive values)	29
SSL, DAF=1	3.14
SSL, DAF=2.8	9
SSL, DAF=17.8	56
min/max soil concentration, mg/Kg	0.489 / 20.2
min/max liquid concentration, mg/L	0.008 / 0.47

Hexavalent Chromium (Cr^{+6})		**StationID**	E025SB037	E025SB038	E025SB038
		SampleID	025SB03703 (3-5ft)	025SB03801 (0-1ft)	025SB03803 (3-5ft)
		DateCollected	12/23/2002	12/23/2002	12/23/2002
Parameter	**Units**				
Initial Soil Concentration	mg/kg		65.8 =	66.7 =	81 =
SPLP Water Concentration	mg/L		2.24 J	0.92 J	3.16 J
Soil mass	kg	0.1			
Water volume	L	2			
Total contaminant mass in soil	mg		6.58	6.67	8.1
Total contaminant mass in water	mg		4.48	1.84	6.32
Adjusted soil concentration	mg/kg		21.0	48.3	17.8
Kd	L/kg		9.4	53	5.6
For DAF = 1, SSL = Kd x MCL					
DAF =	1		1.031	5.775	0.620
DAF =	2.8		2.932	16.419	1.762
DAF =	17.8		18.331	102.655	11.014
MCL, mg/L (Region III Tap Water RBC [HI=1] for Cr^{+6} used in place of MCL)	0.11				
SSL = Kd x MCL x DAF					
geometric mean of Kd (excludes negitive values)	29				
SSL, DAF=1	3.14				
SSL, DAF=2.8	9				
SSL, DAF=17.8	56				
min/max soil concentration, mg/Kg	0.489 / 20.2				
min/max liquid concentration, mg/L	0.008 / 0.47				

Element: Sample Collection and Laboratory Costs
Alternative: 1, 2

Site:	Charleston Naval Complex	**Prepared By:** DFW	**Checked By:**
Location:	AOC 561	**Date:** 03/06/03	**Date:**
Phase:	Corrective Measures study		
Base Year:	2003		

WORK STATEMENT

Costs associated with water sample collection, shipment and analysis on a per event basis; no natural attenuation parameters.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Equipment & Labor per Event					STL estimate
Sample Analysis (VOCs - EPA 8260 - Level II), Metals, Cr6+, Hydrogen Gas	11	SAMPLE	$350	$3,850	10 wells with one QA
Sampling Supplies	1	EA	$200	$200	
Groundwater Sampling Equipment Rental	0.5	WK	$600	$300	Includes MultiRAE and Peristaltic Pump
Sample Shipment	1	EA	$200	$200	CH2M-Jones Estimate
Labor - Technicians	24	HR	$55	$1,320	3 hrs/well, 2 people, includes data validation
SUBTOTAL				**$5,870**	
Project Management	2%	of	$5,870	$117	
Technical Support	2%	of	$5,870	$117	
Construction Management	0%	of	$5,870	$0	
Subcontractor General Requirements	0%	of	$5,870	$0	
SUBTOTAL				**$6,105**	
TOTAL UNIT COST				**$6,100**	

OPERATION AND MAINTENANCE COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
SUBTOTAL				$0	
Contingency	20%		$0	$0	
SUBTOTAL				$0	
TOTAL O&M COST				**$0**	

Source of Cost Data

1. Analytical Bid Form - Charleston Naval Complex - Level III

Alternative GW1: Emplacement of ZVI with LUCs

COST ESTIMATE SUMMARY

Site: Charleston Naval Complex
Location: Combined SWMU 70
Phase: Corrective Measures Study
Base Year: 2002
Date: 06/24/03

Description:
Emplacement of ZVI and monitoring for 20 years

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
Monitoring Work Plan				
Labor - Project Manager	12	HR	$125	$1,500
Labor - Engineer/Hydrogeologist	40	HR	$90	$3,600
Labor - Editor	16	HR	$65	$1,040
Labor - CAD Technician	16	HR	$65	$1,040
Initial Groundwater Sample Collection	1	EA	$6,105	$6,105
Install Monitoring Wells	2	EA	$1,500	$3,000
Additional ZVI and Costs in Install	1	EA	$250,000	$250,000
SUBTOTAL				**$266,285**
Project Management	5%	of	$266,285	$13,314
Technical Support	5%	of	$266,285	$13,314
SUBTOTAL				**$292,913**
Contingency	15%	of	$292,913	$43,937
TOTAL CAPITAL COST				**$336,900**

OPERATIONS AND MAINTENANCE COST

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
yrs 1 - 20	Annual Groundwater Sample Collection	1	EA	$6,100	**$6,100**
	Annual Report				
	Labor - Project Manager	6	HR	$125	$750
	Labor - Engineer/Hydrogeologist	16	HR	$90	$1,440
	Labor - Editor	6	HR	$65	$390
	Labor - CAD Technician	12	HR	$65	$780
	SUBTOTAL				**$3,360**
yrs 1 - 20	**TOTAL ANNUAL O&M COST**				**$9,500**

PRESENT VALUE ANALYSIS

Discount Rate = 3.2%

End Year	COST TYPE	TOTAL COST	COST PER YEAR	TOTAL PRESENT WORTH
1	FIRST YEAR CAPITAL COST	$336,900	$336,900	$336,900
1 - 20	ANNUAL O&M COST (Year 1 - 15)	$190,000	$9,500	$138,758
				$475,658
	TOTAL PRESENT WORTH OF ALTERNATIVE			**$476,000**

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative GW2:	MNA with LUCs	COST ESTIMATE SUMMARY
Site:	Charleston Naval Complex	Description:
Location:	Combined SWMU 70	Emplacement of ZVI and monitoring for 20 years
Phase:	Corrective Measures Study	
Base Year:	2002	
Date:	07/11/03	

CAPITAL COSTS	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
	Monitoring Work Plan				
	Labor - Project Manager	12	HR	$125	$1,500
	Labor - Engineer/Hydrogeologist	40	HR	$90	$3,600
	Labor - Editor	16	HR	$65	$1,040
	Labor - CAD Technician	16	HR	$65	$1,040
	Initial Groundwater Sample Collection	1	EA	$6,105	$6,105
	Monitor Well Installation	2	EA	$1,500	$3,000
	SUBTOTAL				**$16,285**
	Project Management	5%	of	$16,285	$814
	Technical Support	5%	of	$16,285	$814
	SUBTOTAL				**$17,913**
	Contingency	15%	of	$17,913	$2,687
	TOTAL CAPITAL COST				**$20,600**

OPERATIONS AND MAINTENANCE COST	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
yrs 1 - 20	Annual Groundwater Sample Collection	1	EA	$6,100	**$6,100**
	Annual Report				
	Labor - Project Manager	6	HR	$125	$750
	Labor - Engineer/Hydrogeologist	16	HR	$90	$1,440
	Labor - Editor	6	HR	$65	$390
	Labor - CAD Technician	12	HR	$65	$780
	SUBTOTAL				**$3,360**
yrs 1 - 20	**TOTAL ANNUAL O&M COST**				**$9,500**

PRESENT VALUE ANALYSIS Discount Rate = 3.2%

End Year	COST TYPE	TOTAL COST	COST PER YEAR	TOTAL PRESENT WORTH
1	FIRST YEAR CAPITAL COST	$20,600	$20,600	$20,600
1 - 20	ANNUAL O&M COST (Year 1 - 15)	$190,000	$9,500	$138,758
				$159,358
	TOTAL PRESENT WORTH OF ALTERNATIVE			**$159,000**

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative S1: **Capping with LUCs**

COST ESTIMATE SUMMARY

Site: Charleston Naval Complex
Location: Combined SWMU 70
Phase: Corrective Measures Study
Base Year: 2003
Date: 06/23/03

Description: Use Cap to minimize groundwater infiltration supplemented with LUCs

CAPITAL COSTS AND ISOGEN SYSTEM OPERATION

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
	None	-	EA	$0	$0
	SUBTOTAL				**$0**
	TOTAL CAPITAL COST				**$0**

OPERATIONS AND MAINTENANCE COST - Monitoring

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
Yrs 1-20	Annual Cap Inspection/LUC Enforcement	1	EA	$1,000	**$1,000**
	Annual Report				
	Labor - Project Manager	2	HR	$125	$250
	Labor - Engineer/Hydrogeologist	6	HR	$90	$540
	Labor - Editor	4	HR	$65	$260
	Labor - CAD Technician	1	HR	$65	$65
	SUBTOTAL - Annual Report				**$1,115**
Yrs 1 - 20	**TOTAL ANNUAL O&M COST**				**$2,100**

PRESENT VALUE ANALYSIS

Discount Rate = 3.2%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT VALUE
1	FIRST YEAR CAPITAL COST	$0	$0	$0
1 - 20	ANNUAL O&M COST (Year 1 - 20)	$42,000	$2,100	$30,672.73
	TOTAL PRESENT WORTH OF ALTERNATIVE			**$31,000**

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative S2: **Subtask** **COST WORKSHEET 2**

Element: **Soil Excavation and Disposal**

Site:	Charleston Naval Complex	**Prepared By:** SN	**Checked By:**
Location:	Combined SWMU 83	**Date:** 07/11/2003	**Date:**
Phase:	Corrective Measures Study		
Base Year:	2003		

WORK STATEMENT

Excavate soil and haul to disposal area; backfill with clean soil and restore surface to original condition.

Remove and replace pavement.

See quantity calcs

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Mob/demob/decon	4	EA	$1,000	$1,500	
Utility checks and permits	16	HR	$100	$1,600	CH2M-Jones Est.
Air monitoring and sampling					
Asphalt cutting	260	LF	$1.15	$299	CH2M-Jones Est.
Pavement removal	2100	SF	$5.00	$10,500	CH2M-Jones Est.
Excavation (soil) - machine	2	weeks	$3,000	$6,000	CH2M-Jones Est.
Pavement disposal - Non-Haz	500	tons	$45	$22,500	CH2M-Jones Est.
Clean Fill	267	CY	$15	$4,005	CH2M-Jones Est.
Compaction machine	3	day	$50	$150	CH2M-Jones Est.
Replace asphalt	2100	SF	$2	$4,200	CH2M-Jones Est.
Site Operator-Oversight	60	HR	$100	$6,000	CH2M-Jones Est.
Waste characterization TCLP	3	EA	$150	$450	
Contam Soil disposal - Non-Haz	464	Tons	$45	$20,880	CH2M-Jones Est.
SUBTOTAL				$78,084	
Allowance for Misc. Items	40%		$78,084	$31,234	30% Scope + 10% Bid
SUBTOTAL				$109,318	
TOTAL UNIT COST				**$109,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
SUBTOTAL				$0	
Allowance for Misc. Items	20%		$0	$0	
SUBTOTAL				$0	
TOTAL ANNUAL O&M COST				**$0**	

Source of Cost Data

1. Means. 2002. Environmental Remediation Cost Data - Assemblies, 8th Edition. R.S. Means Company Kingston, MA.
2. CH2M-Jones -historic costs for CNC excavations at other sites, 2001-2002.

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